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#205 JUNE 2022

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Welcome

A Sun-like star reveals clues about Earth's distant future

Recently, astronomers made a one-in-a-million discovery: a Jupiter-like planet that had survived the death of its star. This first find of its type was even more remarkable because the star in question is – or rather was – like our own star, the Sun. They had on their hands a case study for what will happen to the Solar System billions of years from now, when the solar furnace at its centre runs out of fuel. Colin Stuart tells the story of this window into the eventual fate of our planetary system on **page 66**.

Meanwhile, here in Earth's Northern Hemisphere, with the June solstice just around the corner, we astronomers aren't wishing for an end to the Sun but we might be yearning for less of it every 24 hours, and the return of longer nights. While this isn't the month to go after faint nebulae don't mothball your setup just yet. On **page 28**, Will Gater shows there are still many satisfying targets to observe and image, from glittering star clusters to enchanting planetary alignments.

Pete Lawrence and Steve Tonkin continue this theme in the 'Sky Guide' on **page 43** too, where they have detailed coverage of more wonderful targets to see and image in high summer's night skies, including the start of noctilucent cloud season.

And do turn to Ezzy Pearson's feature on **page 34**. She speaks to six professional astronomers to uncover the huge variation of roles covered by that one job title – all helping to make fascinating discoveries like the one on our cover.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 16 June.

HOW TO CONTACT US

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

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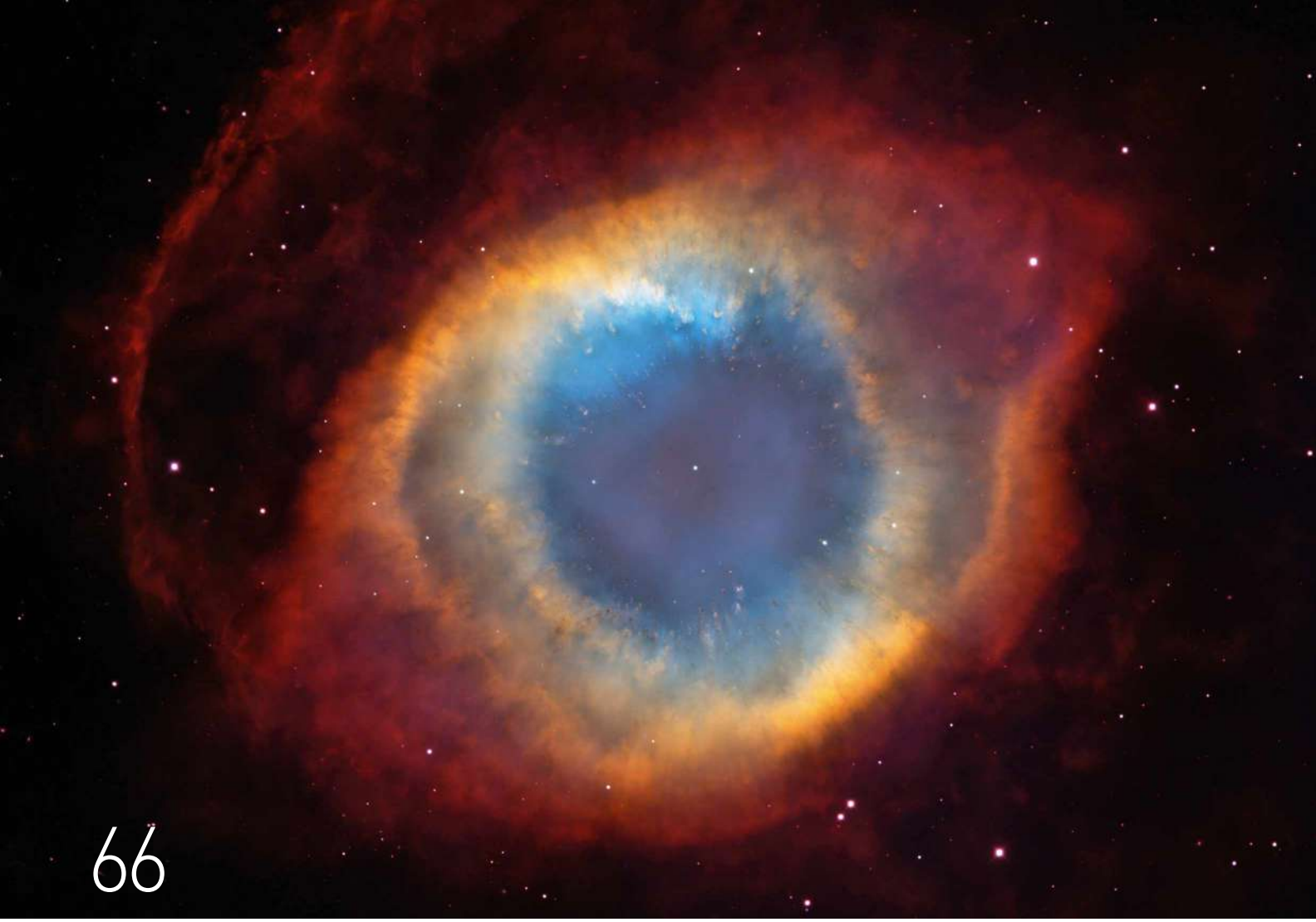

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The Sky Guide

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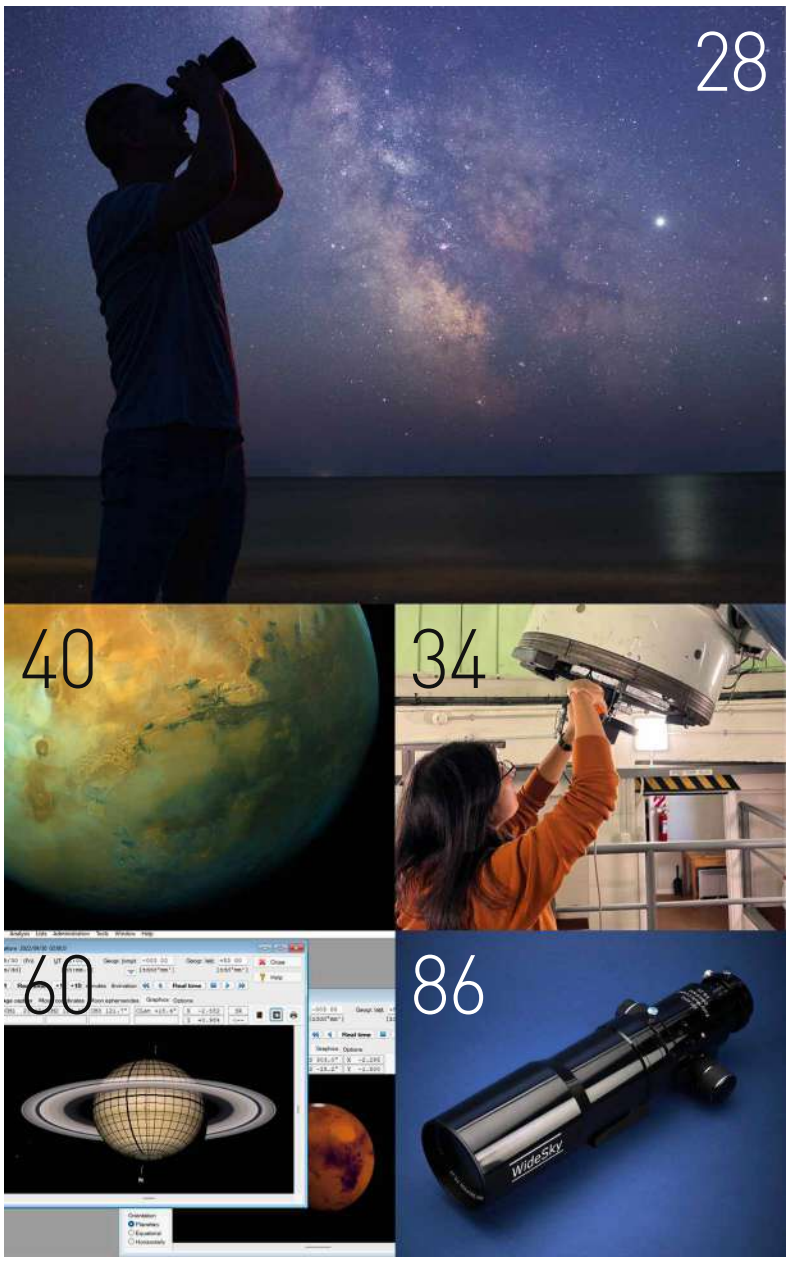
COVER IMAGE: SOLARSEVEN/ISTOCK/GETTY IMAGES. THIS PAGE: NASA/ESA/C.R. O'DELL (VANDERBILT UNIVERSITY)/AND M. MEIXNER/P. MCCULLOUGH AND G. BACONS, M-GUCCI/ISTOCK/GETTY IMAGES, WILL GATER X 2, NICOLE TAN, E.MIRATES MARS MISSION @THESHED_PHOTOSTUDIO, DR EVA- MARIA MUELLER

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**



This month's contributors

Melissa Brobby

Amateur astronomer

"I really enjoy talking to astronomers about their work, and it was fascinating to learn about black holes from Joanna Piotrowska this month." **Melissa meets a galaxy evolution scientist,** page 98

Ezzy Pearson

News editor

"It was very interesting to talk to so many people filling the many different roles that fall under the umbrella of 'astronomer'." **From queue observers, to simulation builders, Ezzy meets six pro astronomers,** page 34

Colin Stuart

Astronomy writer

"I find it fascinating that not only could some planets survive the death of the Sun, but doing so might make them more habitable." **Colin reflects on new evidence about the eventual fate of our Solar System,** page 66

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/GHSYREX/** to access this month's selection of exclusive Bonus Content

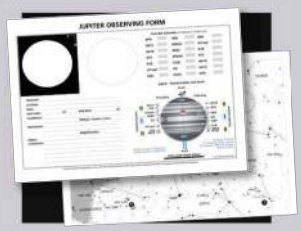
JUNE HIGHLIGHTS

Interview: Searching for dark energy

The Universe's expansion is accelerating. Dr Eva-Maria Mueller reveals how we might understand why.

Audiobook preview: *Never Panic Early*

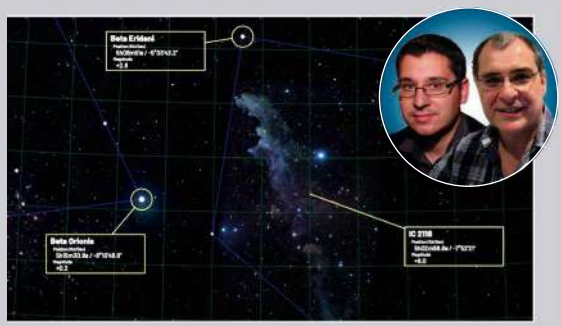
Download and listen to the first chapter of a new autobiography written by the Apollo 13 Lunar Module Pilot Fred Haise.



Plan your observing for the month ahead

Access charts to record your observations of the planets and take this month's binocular and deep-sky tours.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

STILL AMAZING AFTER ALL THESE YEARS

It may now be in the twilight of its life, but Hubble continues to bring us stunning visions of the Universe

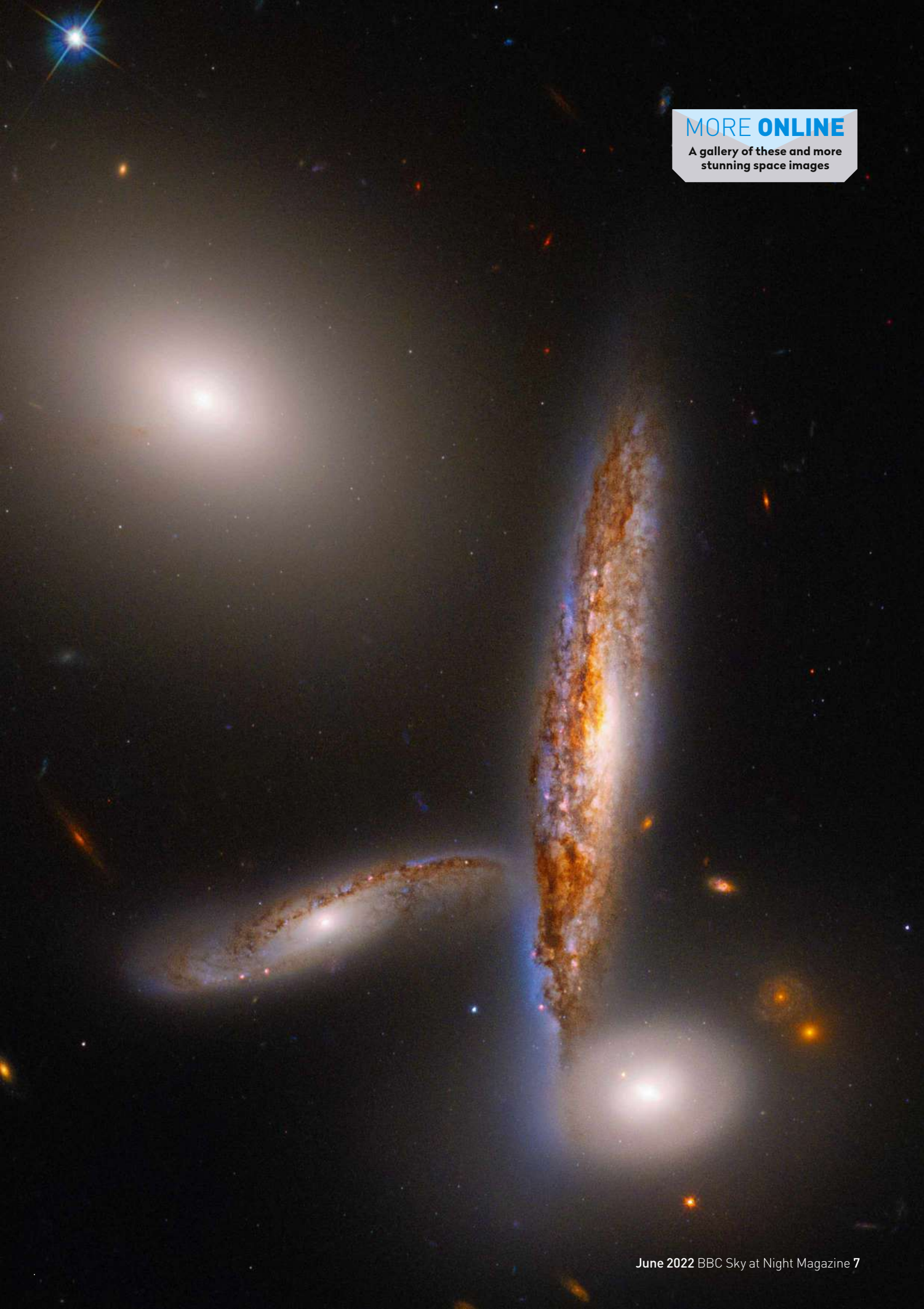
HUBBLE SPACE TELESCOPE, 19 APRIL 2022

Thirty-two years since its launch atop Space Shuttle Discovery on 24 April 1990, countless extraordinary insights and well over a million mind-blowing images later, the Hubble Space Telescope is still delivering the goods.

This photo shows the Hickson Compact Group 40, with five prominent galaxies – three spirals, an elliptical and a lenticular – in the constellation of Hydra, squashed together in an area less than twice the width of our galaxy (hence the name 'compact'). Released to mark Hubble's 32nd birthday, it's a perfect example of the kind of beauty the venerable telescope still routinely reveals from its unobstructed vantage point 547km above Earth.

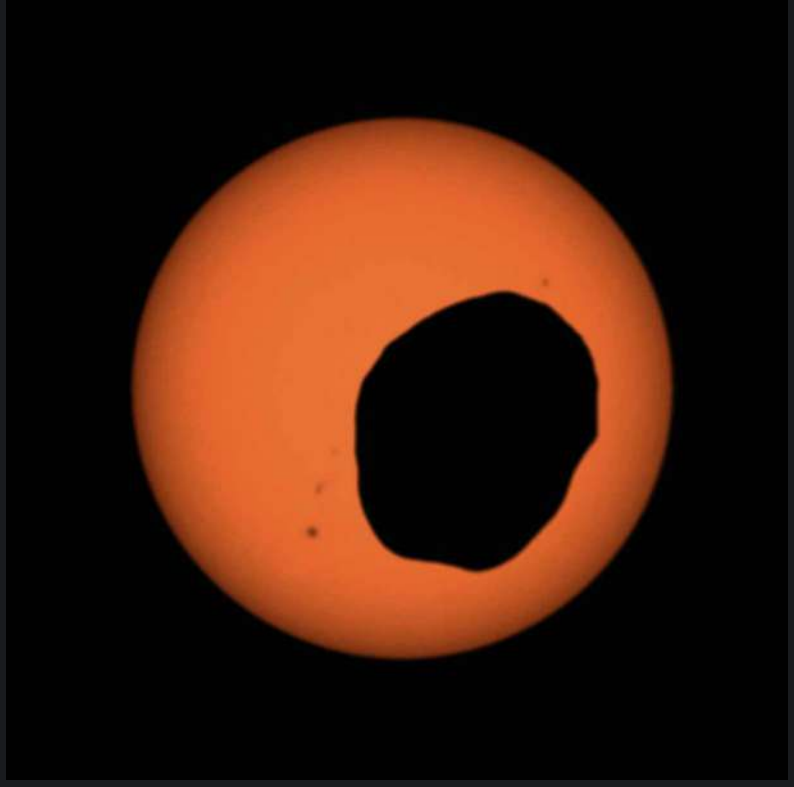
It may be ailing now, spending several weeks offline recently and physically unrepairable since the end of the Space Shuttle programme, but Hubble – originally on a 15-year mission – remains funded until 2026. The James Webb Space Telescope will release its first proper images any day now and the bigger and far more powerful space observatory promises unimaginable new revelations about the Universe. But it's going to be a sad day indeed when one of Hubble's 1980s components finally gives up the ghost and we lose its eye on the sky.

SCIENCE: NASA/ESA/STSCI IMAGE PROCESSING: ALYSSA PAGAN (STSCI)



MORE **ONLINE**

A gallery of these and more stunning space images



◁ Phobos crossing

PERSEVERANCE, 2 APRIL 2022

With 23 cameras, Perseverance has eyes in the back of its head, so as it trundled within Jezero Crater it was also able to capture this: Phobos, one of Mars's two moons, crossing the Sun. The highest-frame-rate video ever taken of Phobos from the Martian surface, it shows the moon transiting from right to left in 40 seconds.

▽ Black hole diet tips

CHANDRA X-RAY OBSERVATORY, HUBBLE SPACE TELESCOPE, 20 APRIL 2022

Puny black holes may bulk up and put on weight by obliterating loads of stars. The four galaxies here are among 29 in which stellar carnage has been observed around black holes. It's thought the small stellar-mass singularities grow into intermediate-mass ones in a process triggered by stars clustering in high densities.

NASA/JPL-CALTECH/ASU/MSSS/SSI, X-RAY: NASA/CXC/VYASHINGTON STATE UNIV./V. BALDASSARE ET AL.; OPTICAL: NASA/ESA/STSCI, KPNO/NOIRLAB/NSF/AURA, NASA/JPL-CALTECH

△ Baffling bubble

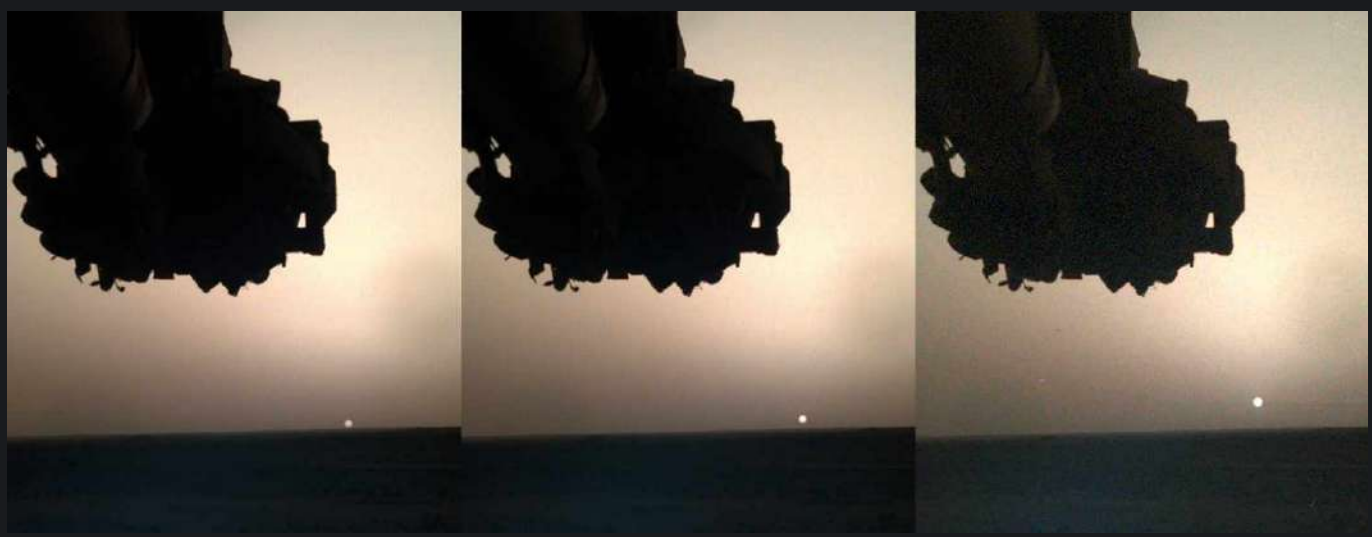
NICHOLAS U MAYALL 4-METRE TELESCOPE, 13 APRIL 2022

Ancient, large and extremely faint planetary nebula EGB 6, near Regulus in Leo, the Lion, continues to puzzle researchers. Discovered in 1978 and catalogued in 1984 by Glenn Ellis, Earl Grayson and Howard Bond (EGB), it's the cast-off shell of a star that collapsed 20,000 years ago, a blink of an eye in cosmic terms. For a star in its death throes, it has unexpectedly dense knots of nebulosity and a curiously dust-shrouded companion star, whose connection to the white dwarf core is so far unknown.

▽ Martian sunrise

INSIGHT, 10 APRIL 2022

This composite shows the Sun rising on Martian sol 1,198, as captured by NASA's InSight lander. Unlike the Perseverance and Curiosity rovers, InSight doesn't roam the Red Planet, but conducts its mission from the spot where it landed in November 2018, relying on the power of the Sun to charge its two 2.2m-wide solar panels. This brief look at the Sun aside, the lander's main focus is the ground, measuring subsurface temperature in the planet's crust, mantle and core; marsquakes; and meteorite strikes.



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The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

Hubble finds the farthest star ever seen

The record-breaking star was found with the help of a chance alignment

The Hubble Space Telescope has observed what could be the earliest star ever seen, which appears to date from when the Universe was just a billion years old, and is a potential member of the very first primordial generation of stars.

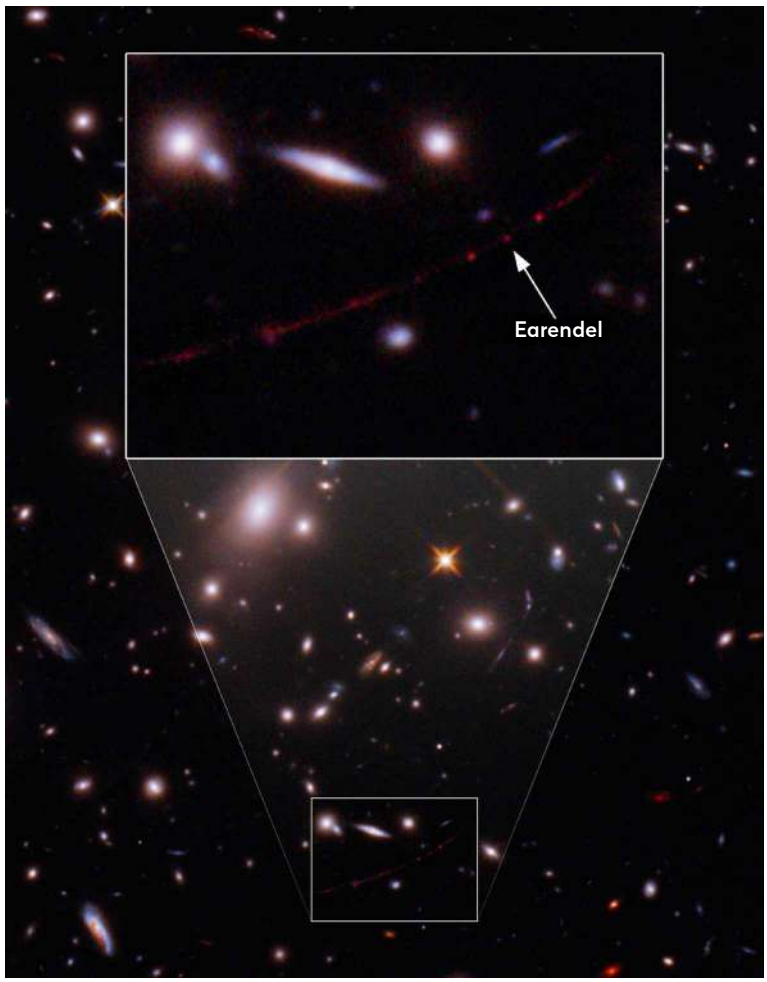
Hubble was only able to spot the star – called Earendel, meaning 'morning star' in Old English – because its light was bent and magnified by a foreground galaxy cluster in a process known as gravitational lensing.

"Normally at these distances, entire galaxies look like small smudges, with the light from millions of stars blending together," says Brian Welch from the Johns Hopkins University, who led the discovery. "The galaxy hosting this star has been magnified and distorted by gravitational lensing into a long crescent that we named the sunrise arc."

This alignment made Earendel's light stand out from the rest of the galaxy, allowing astronomers to see it. Fortunately, this alignment should hold for another few years, meaning the James Webb Space Telescope (JWST) can observe the star when it becomes fully operational later this year. Though Hubble has been able to determine the star's age and that it weighs 50 solar masses, JWST is sensitive enough to learn more about the star's brightness, temperature and composition as well.

"Studying Earendel will be a window into an era of the Universe that we are unfamiliar with, but that led to everything we do know," says Welch. "It's like we've been reading a really interesting book and we started with the second chapter. Now we will have a chance to see how it all got started."

https://hubblesite.org



▲ This most distant star, Earendel, is positioned in line with a ripple in spacetime that gives the galaxy it lies in extreme magnification

NASA/ESA/BRIAN WELCH (JHU), DAN COE (STSCI)/NASA/ESA/ALYSSA PAGAN (STSCI)

Comment

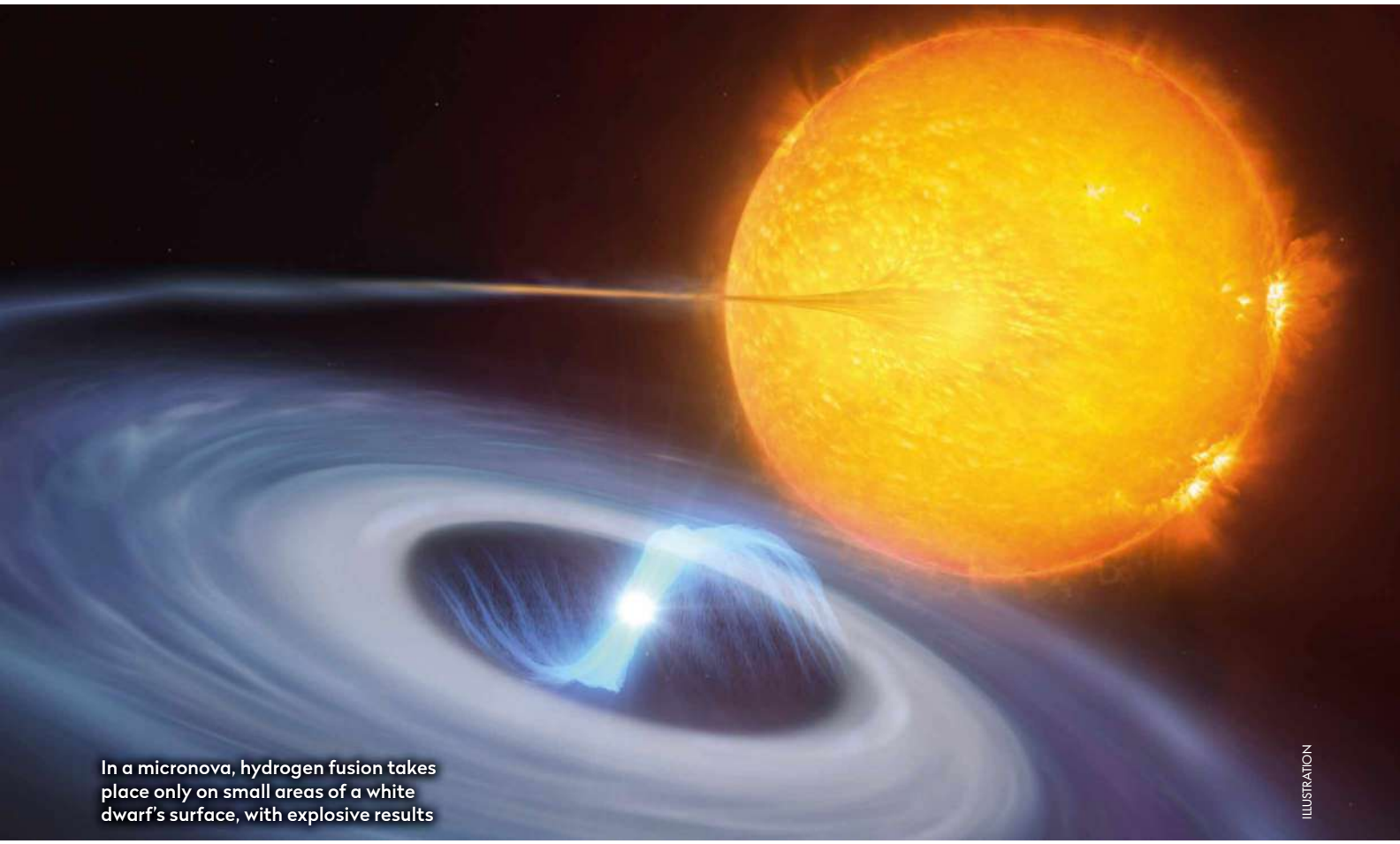
by Chris Lintott

We'll need JWST to get to the bottom of what this Earendel star actually is. Until we get spectra of the object from our new space telescope, the possibility remains that the location of the star on the arc of light produced by the galaxy cluster lens is nothing more than a coincidence.

The team behind the paper estimates the probability of a Milky Way star just happening to end up in such a place is one in ten thousand; others are more sceptical. They do point out that there's no sign of the star moving relative to the background source, so it is at least not very nearby.

Whether this turns out to be the most distant star ever seen, or just an interloper, it's whetted appetities for JWST even further. With science observations now scheduled following deployment, it won't be long before we learn a lot more about the early Universe Earendel seems to inhabit.

Chris Lintott co-presents *The Sky at Night*



In a micronova, hydrogen fusion takes place only on small areas of a white dwarf's surface, with explosive results

ILLUSTRATION

ESO/M. KORNMESSER/L. CALÇADA, NASA, NASA/ESA/ZENA LEVY (STSCI), NASA/ESA/JOSEPH OLMSTED (STSCI)

Newly found micronovae still pack a punch

Previously unknown stellar explosions are small, but only in comparison to other types

Astronomers have discovered a new kind of stellar explosion, called a micronova. But don't be deceived by its seemingly diminutive name – these are actually colossal stellar explosions which can consume 20 million trillion kg of material in just a few hours.

The explosions were first discovered by NASA's exoplanet-hunting satellite, TESS, which found three white dwarf stars that emitted a bright flash of light, lasting a few hours. After follow-up observations from ESO's Very Large Telescope, they were found to be miniature versions of previously known stellar explosions known as novae (not to be confused with supernovae, a different stellar event type).

Novae occur when a white dwarf steals material from a larger companion star. When this kidnapped hydrogen gas hits the hot surface of the dwarf, it immediately fuses into helium – with explosive results. In previously known cases, this occurred across the whole surface of the star, creating a nova which could burn for a week. For stars with strong magnetic fields, however, the incoming material gets syphoned down onto the poles.

"For the first time, we have now seen that hydrogen fusion can also happen in a localised way," says Professor Paul Groot from Radboud University, who helped lead the study. "The hydrogen fuel can be contained at the base of the magnetic poles of some white dwarfs, so that fusion only happens at these magnetic poles. This leads to micro-fusion bombs going off, which have about one millionth the strength of a nova explosion, hence the name micronova."

As well as discovering a new mechanism for how these stellar explosions occur, the find could also mean nova-like events are not as rare as previously thought.

"These events might be quite common, but because they are so fast they are difficult to catch in action," says Dr Simone Scaringi from Durham University, who led the study. "The phenomenon challenges our understanding of how thermonuclear explosions in stars occur. We thought we knew this, but this discovery proposes a totally new way to achieve them. It just goes to show how dynamic the Universe is."

https://tess.mit.edu/

NEWS IN BRIEF

▲ **Artemis 1 has returned to the Vehicle Assembly Building for repairs, but NASA is still optimistic about a launch, at the earliest in August**

Artemis 1 rolled back for repairs

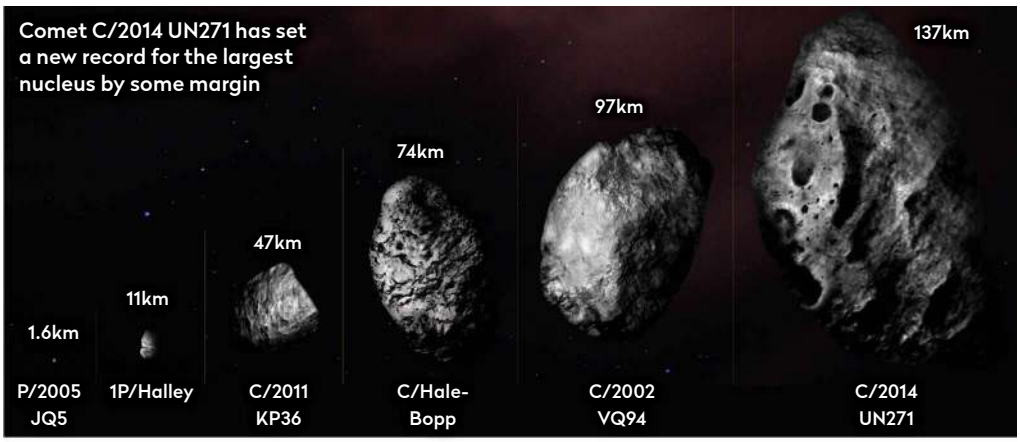
A faulty valve and fuel line cause delays until August

Artemis 1 was rolled back off the launch pad on 25 April, following three failed attempts at its wet dress rehearsal – when the Space Launch System (SLS) rocket is filled with fuel and runs through the launch countdown procedure – in early April.

These tests revealed a hydrogen fuel leak in one of the rocket's umbilical lines and a faulty valve on the upper stage, meaning it had to return to the Vehicle Assembly Building (VAB) for repairs. The 5.6km journey back to the VAB took 10 hours, arriving at around 6am on 26 April. The team hope to have the rocket ready for an August launch.

"We'll absolutely go back out; we're absolutely going to do a wet dress rehearsal," said Tom Whitmeyer, NASA's Associate Administrator for Common Exploration Systems Development. "It's just a matter of what's the right time, what's the right way to do that."
www.nasa.gov

Comet has the biggest heart

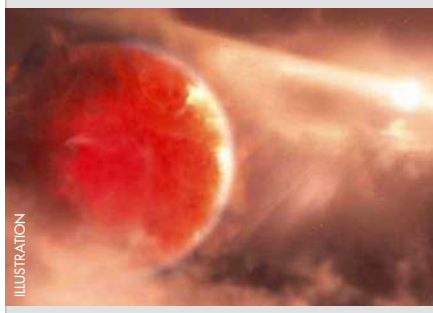


ILLUSTRATION

While comets are best known for their tails, which can arc for millions of kilometres across the Solar System, their icy cores are usually only a few kilometres across. However, Hubble has revealed that a gargantuan comet is currently making its way through the Solar System, after recent observations showed the icy heart of C/2014 UN271 is over 135km across – making it the largest comet nucleus known.

Comets are the icy leftovers of planet formation that have survived on the outskirts of our Solar System. Those with long periods, such as this one – which takes three million years to orbit the Sun – are thought to originate from the hypothetical Oort Cloud, which is too far away to see directly.

"This comet is the tip of the iceberg for thousands of comets that are too faint to see in the more distant parts of the Solar System," says David Jewitt from the University of California, who took part in the study. "We suspected this comet had to be big because it is so bright at such a large distance. Now we confirm it is."
https://hubblesite.org



ILLUSTRATION

Infant gas giant

Astronomers have discovered evidence of a gas giant planet in its earliest stages of formation. Intriguingly, it appears to be forming 'top-down' – where the disc of dust surrounding a planet breaks apart – rather than by the dominant 'bottom-up' theory of planet creation, when material gathers slowly over time.

Amateur astronomers' awarded accolades

Two amateur astronomy projects have received an award from the Astronomical Society of Australia for their scientific merit: The Backyard Observatory Supernova Search, which has found 200 confirmed supernovae; and Trevor Barry, who tracked an electrical storm on Saturn for seven months.

SKA will have a British brain

The government has awarded £15m to several UK institutions to build the software that will control the Square Kilometre Array. The recipients include the Universities of Cambridge, Manchester and Oxford, as well as the Rutherford Appleton and Daresbury STFC Laboratories.

NEWS IN BRIEF

ILLUSTRATION

Infant black hole is unearthed

The embryo of a supermassive black hole, dating from just 750 million years after the Big Bang, has been discovered buried in archival data from the Hubble Space Telescope. The discovery could yield vital clues to how these cosmic colossi found at the heart of many galaxies grow to their enormous size.

The masses map Mars

Members of the public have helped map out the surface of Mars by identifying unusual ridge features. So far the 'Planet Four: Ridges' project has mapped 20 per cent of Mars's surface in the region surrounding Jezero Crater, where the Perseverance rover is currently exploring, but hopes to eventually map the whole surface. Find out more at **https://bit.ly/P4Ridges**

Galactic record breaker

A galaxy has been spotted 13.5 billion lightyears away, breaking the record for the most distant astronomical object ever seen by 100 million lightyears. The object, HD1, was observed over 1,200 hours by four telescopes: Subaru, VISTA, UK Infrared and Spitzer.

ESA/HUBBLE/N. BARTMANN, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE/ISAAC HERRERA/KELSI SINGER, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE/KELSI SINGER, ESO/M. ROMAN, NAOJ/SUBARU/COMICS

BULLETIN

Pluto's ice volcanoes shaped its heart

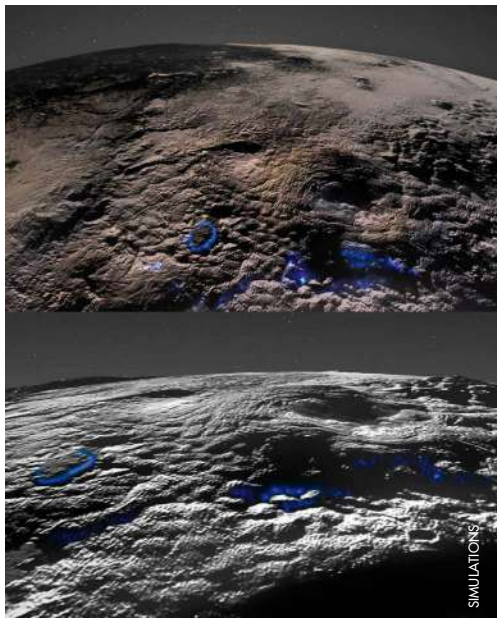
Beneath the dwarf planet's surface, ice flows like lava

The unique hills of Pluto's icy heart-shaped region were probably formed by cryovolcanism – when water and ice act like lava and rock.

"Rather than erosion, cryovolcanic activity appears to have extruded large amounts of material onto Pluto's exterior and resurfaced an entire region of the hemisphere New Horizons saw up close," says Kelsi Singer from New Horizons, which flew past Pluto in 2015.

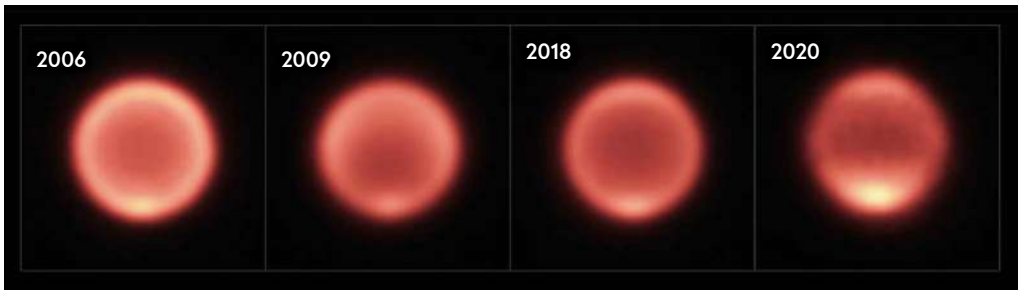
The region in question is the bright plain called Sputnik Planitia. Close inspection of New Horizons images of the region show it is covered in huge domes up to 7km tall and 100km wide, which the study found could be created by repeated cryovolcanic eruptions of material with a toothpaste-like consistency.

Few if any craters exist in the area, indicating it is geologically young. This raises the possibility that Pluto's interior structure retained heat into the relatively recent past, to make it possible for material to be deposited on the surface.
http://pluto.jhuapl.edu/


SIMULATIONS

▲ **Astronomers have indicated areas, in blue, where cryovolcanism may have occured on Pluto**

Southern summertime on Neptune



▲ **A recent warming in temperature at Neptune's southern pole has been detected by astronomers**

The weather could be taking a turn for the better in Neptune's southern hemisphere, after a long-term monitoring project has measured a recent jump in temperature at the pole.

Ground-based telescopes have been monitoring the atmospheric temperature on Neptune since 2003. The planet's southern hemisphere began its summer in 2005, but change has been slow as each season lasts around 40 years. Between 2003 and 2018, the team noticed a steady drop in global temperature of around 8°C. However, this jumped abruptly when the south pole's temperature rose by 11°C in just two years, between 2018 and 2020.

"Temperature variations may be related to seasonal changes in Neptune's atmospheric chemistry, which can alter how effectively the atmosphere cools," says Michael Roman from the University of Leicester, who led the study. "But random variability in weather patterns or even a response to the 11–year solar activity cycle may also have an effect. This all points towards a more complicated picture of Neptune's atmosphere and how it changes with time."
https://le.ac.uk

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This unique design features an exposed gear train that controls the speed and ratio of the orbits of the planets as they move around the sun. Made from solid brass, the gears and hand-polished and lacquered to minimise tarnishing.

Fashioned from silver-plate, your planets are hand painted to capture the nature and defining characteristics of the real planets.

An Original Design

The solar system model is adapted from an original 1980s design by British engineer, inventor and metal worker Louis Calmels. This version was first created in 2008 and and was endorsed by Sir Patrick Moore who said "This Orrery is attractive and accurate and I heartily recommend it".

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CUTTING EDGE

Seamus Anderson at the site where a drone found a meteorite

Drones used to hunt for meteorites

Using drones could improve our odds of finding 'fresh' meteorites

Studying the composition of meteorites provides vital clues about what was happening in the early Solar System and how the planets in it formed. By far the greatest insights are provided by meteorites, particularly the fallen space rocks that can be collected immediately, before they have a chance to become weathered and contaminated by lying on Earth's surface. Over recent years, automated networks of sky-watching cameras have enormously increased the rate at which meteors can be detected while they're still fireballs falling through Earth's atmosphere. In some cases, the fireball's trajectory can be extrapolated forwards to predict roughly where the meteorite fragments will land, as well as backwards to determine the orbit of the original meteoroid. Recovered meteorites with a known point of origin are uniquely useful.

The problem is, even with an observed fall, it can be enormously labour intensive and time consuming to find the small meteorite fragments. It relies on a team of five or more people, walking in regularly spaced lines, scouring the ground over several square kilometres, and even then the success rate is low. But Seamus Anderson and his colleagues at the Space Science and Technology Centre, Curtin University, in Australia, think they have the solution. They've developed a technique that uses drones to rapidly photograph large areas around the predicted fall site, and machine learning software to identify potential meteorite candidates in the images.

> ***"The problem is, even with an observed fall, it can be enormously labour intensive and time consuming to find the small meteorite fragments"***

Aerial photography

They tested their newly developed system in April last year. Two cameras in the Desert Fireball Network in Western Australia detected a bright, three-second fireball and automatically alerted Anderson's team of scientists. It was observed down to an altitude of 25km while lancing through the atmosphere at an angle of 64°, and from this trajectory the likely fall line along the ground was calculated. Anderson and his team spent three days surveying the 5km^2 search area, taking tens of thousands of photos with a drone. After each flight, their computer program, based on a neural network – a simple, artificial brain that had been trained to recognise blackened meteorites lying on the ground – processed the images and highlighted potential fragments. These meteorite candidates were then remotely checked by the drone, which would return to the specific locations on autopilot and hover just a metre above the ground to take high-resolution images. Anderson's team then checked the close-up photos to confirm which ones were most likely to be meteorites and only then visited the specific locations to retrieve the rocks.

Anderson and his team were rewarded with the discovery of a 70g piece of the meteorite, which was found just 50m from the fall line predicted by the fireball tracking. This is the first time that a 'fresh' meteorite has been recovered using such a strategy, and it represents a huge saving in time and effort for scientists. There's still room for improvement in the system, though, according to Anderson. The automated process flagged up a number of false-positives – objects on the ground that weren't actually meteorites. They included tin cans, bottles and even kangaroos!

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Successful Recovery of an Observed Meteorite Fall Using Drones and Machine Learning* by Seamus L Anderson et al. **Read it online at: arxiv.org/abs/2203.01466**

CURTIN UNIVERSITY, UGURHAN/ISTOCK/GETTY IMAGES

Did cosmology kill the dinosaurs?

Maybe the asteroid that killed the dinosaurs wasn't the real culprit – perhaps gravity was to blame

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Professor Leandros Perivolaropoulos of the University of Ioannina in Greece is clearly not someone who shirks from a challenge. In a flurry of papers released last year, he suggests a solution to one of the biggest problems in modern cosmology. Now he thinks that the same explanation may account for why the dinosaurs died when they did. Not bad for a year's work.

Let me explain. The cosmological problem Perivolaropoulous addresses concerns the speed of the expansion of the Universe, most often expressed as a number called the Hubble Constant. The Hubble Constant measures the current speed of expansion, and there are two main methods of measuring it: we can either look around us, using so-called 'standard candles' such as Type 1a supernovae to measure it; or we can look at the early Universe, specifically at the cosmic microwave background, and extrapolate to the present day. In recent years, these two methods have both improved in accuracy, but they disagree with one another, causing something of a crisis.

Has gravity really got stronger?

The world isn't short of suggestions for how to fix the problem, ranging from possible errors in the complex analysis carried out in each case, to exotic new theories of cosmology. Perivolaropoulos is in the second camp, as he suggests that the observations can be reconciled with each other by a recent change in the strength of gravity. 'All' that has to happen is for gravity to have become about 10 per cent stronger sometime in the recent past. Such a change would alter the properties of all the objects, such as supernovae, we observe and thus allow cosmologists to resolve their disagreements. A change within the last 150 million years would do nicely.

Which brings us to the dinosaurs. You can't change gravity without having an effect on the orbit of Earth and pretty much everything else. Earth would have got hotter, something Perivolaropoulos claims, unconvincingly, to see reflected in the temperature records. On the outskirts of the Solar System, the odds of objects in the Oort Cloud – the major reservoir of comets – being slung into the inner Solar System increase as gravity does. More incoming comets means more impacts like the one that caused the extinction of the dinosaurs. If the transition in gravity hadn't happened, giant lizards may have continued to walk on Earth.

> ***"The odds of objects in the Oort Cloud – the major reservoir of comets – being slung into the inner Solar System increase as gravity does"***

Now, I don't believe Perivolaropoulos's theory. It seems too much of a coincidence to have such a dramatic change in physics happen just before we appeared with our telescopes and equations to study it. I also don't think adding several more layers of speculation to explain the geological record helps much.

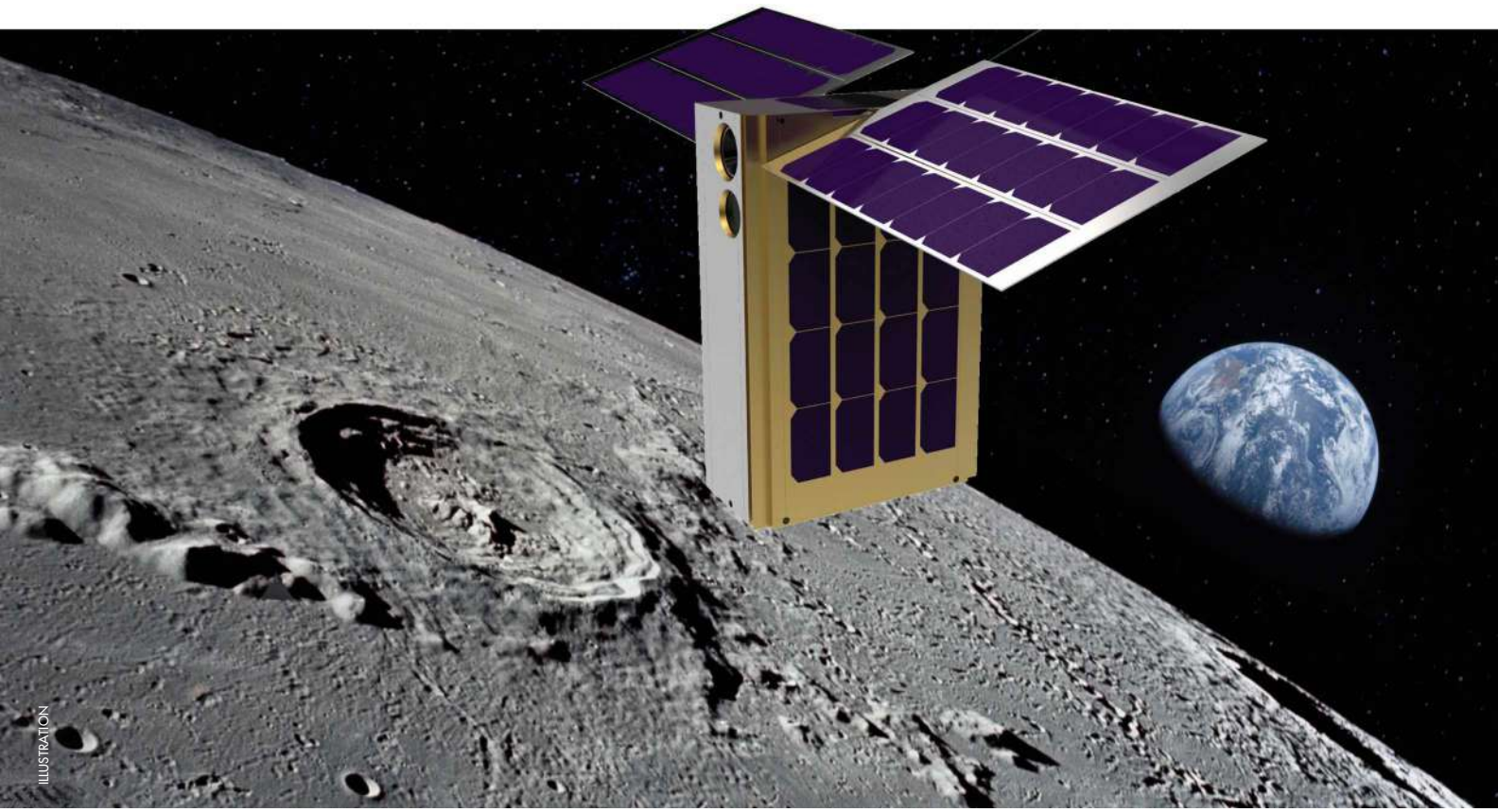
Fun though it is to speculate, if you want me to believe in changing gravity then put dinosaurs aside and explain why such a change could only have happened recently, or work out if the strength of gravity could be always changing instead of requiring one sudden move. Or just work out a way to test the ideas directly. Until then, thinking about what happened to the dinosaurs is strictly for the birds.

Does it stack up that the asteroid which wiped out the dinosaurs was the result of a transition in gravity?

Chris Lintott was reading... *Is the Hubble crisis connected with the extinction of dinosaurs?* by Leandros Perivolaropoulos.
Read it online at: arxiv.org/abs/2201.08997

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



ILLUSTRATION

In May's episode of *The Sky at Night*, **Craig Hardgrove** introduced us to the LunaH-Map orbiter, which will soon be mapping ice in the lunar pole

Back in July 2021, my wife and two kids dropped me off at work so I could pick up the LunaH-Map orbiter, pack it up into a case, board a plane and deliver it to NASA's Kennedy Space Center to be loaded onto the Space Launch System (SLS) rocket. My special delivery, the LunaH-Map (Lunar Polar Hydrogen Mapper), is actually about the size of a large breakfast cereal box. It is a lunar orbiter that will be launched on the same rocket as the Artemis mission and will make maps of the water-ice across the Moon's south pole.

The LunaH-Map is unique. It has a body made primarily of a light aluminium alloy, with lots of holes to reduce its mass. While its eyes are made of neutron sensitive crystals that burst with colour in the presence of a neutron or gamma ray, its solar panels absorb all the sunlight that touches them in order to create power. The LunaH-Map communicates using a deep-space radio transceiver and gets around using heated iodine molecules, accelerated out from its back. It's not healthy to anthropomorphise a spacecraft too much, but the LunaH-Map is almost the same size and weight as my real kids, so it's hard not to make a comparison! I felt like a proud dad when I took off the last 'remove-before-flight' plug and placed it into the SLS a year ago.

Getting a mission off the ground

However, the journey began back in 2014, when I put in the proposal. I was four years out of my PhD and wondering why my career hadn't taken off. After several attempts at getting funding that went nowhere, I gave it one last-ditch effort – a complete planetary mission proposal from start to end. The mission became LunaH-Map and to almost everyone's surprise, it was selected by NASA for their Small Innovative Missions for Planetary Exploration programme. In the noments after I found this out I was both elated and terrified. The mission had just a small per cent of a usual planetary budget, raising a host of questions about how we would pull it off. I

▲ The LunaH-Map (Lunar Polar Hydrogen Mapper) orbiter (inset) will travel to the Moon this year to help investigate traces of water-ice on the lunar surface

NASA X 2, GETTY, NASA/JPL, DAVID LEVENSON/GETTY

Craig Hardgrove is an Assistant Professor at Arizona State University and the Principal Investigator of the LunaH-Map mission

would love to say that I had answers to those questions, but in hindsight, I think it takes someone with less experience and a willingness to learn to drive missions forward in these scenarios.

All the technologies that enable LunaH-Map's scientific measurements were developed over the past seven years, and the spacecraft was assembled in the clean rooms at Arizona State University in early 2021. As LunaH-Map was a small mission with a small team, I've had to spend time handling not only the scientific aspects of the mission, but management, system engineering, navigation, operations, sub-contractor relationships and licensing – the list goes on.

In some ways a new mission like this needed someone a bit naïve, and I'm happy to be the guinea pig for NASA as we figure out together how to make these very small, high-risk, high-reward missions a reality in the future. All that said, I think we did a great job with the resources we had. The spacecraft we delivered to NASA is in great shape and is capable of completing its scientific mission at the Moon.

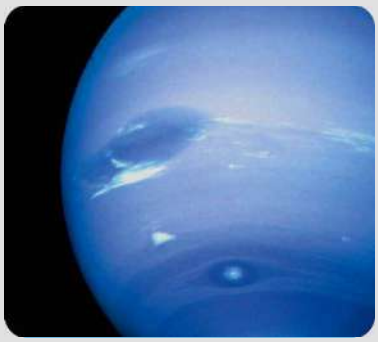
I could not be happier because, in a few short months, the LunaH-Map orbiter – strapped to a 5.75 million pound rocket capable of 8.8 million pounds of thrust – will be launched to the Moon, accelerating from Earth at over 4G.

Looking back: The Sky at Night

6 June 1981

On the 6 June 1981 episode of *The Sky at Night*, Patrick Moore was joined by planetary scientist Garry Hunt to discuss an event that wasn't to happen for another eight years – Voyager 2's encounter with Neptune.

At the time, Voyager 1 had already flown past Jupiter and Saturn, while Voyager 2 was due to encounter Uranus in 1986 and Neptune in 1989. Back then, Neptune was an unknown: just a distant dot in the sky barely visible to the naked eye, which had never had close-up analysis. Itwas so faint that it wasn't discovered until 1781, when astronomer William Herschel mistook it for a comet, only realising he had found a new member of the Solar System two years later.



▲ **Voyager 2 revealed Neptune as a world ravaged by storms**

It wasn't until 25 August 1989, when Voyager 2 flew past Neptune, that we were able to get our first real look at the distant planet – an encounter which revealed more than a few surprises. Rather than the calm, frigid ice giant that was expected, Voyager 2 revealed several dark spots in the planet's blue atmosphere, where storms blew with some of the fastest winds measured in the entire Solar System. Wind speeds were found to be as high as 2,500km/h.

Although Voyager 2 remains the only mission to have visited Neptune, improvements to ground and space-based telescopes mean that we have been able to keep track of the planet from afar as it makes its 165-year journey around the Sun.

The Astronomer Royal at 80

Professor Martin Rees has held the position of the UK's Astronomer Royal since 1995. Today, he is known as a worldwide authority on the subjects of cosmology, the future of spaceflight and the prospect of finding life beyond Earth. To celebrate his 80th birthday, in this episode he looks back over the biggest discoveries and achievements over 50 years of astronomy.

BBC Four, **13 June**, 10pm (first repeat BBC Four, **16 June,** time tbc)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ **The Astronomer Royal reviews pivotal events in astronomy over five decades**

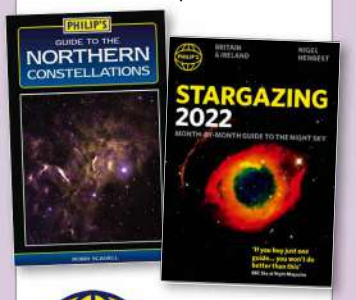
Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

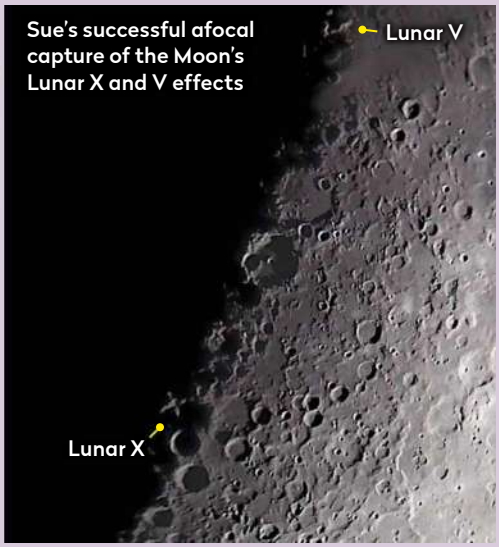
This month's top prize:
two Philip's titles



The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

A simple yet dramatic capture



This is an image of the Moon's clair-obscur effects, the Lunar X and V, as taken on Friday 8 April around 9:30pm, which were forecast in *BBC Sky at Night Magazine*. They are sometimes elusive from my location as they appear either at daytime or after the Moon has set.

I was at my usual Friday night haunt, the Chesterfield Observatory on the evening of the 8th. Here, we are lucky enough to have a big 18-inch reflector housed in the dome, so I took my chance. This all sounds like technical stuff, but the reality is that this was taken using my old, 'not too smart' phone, handheld to the 40mm eyepiece in the 18-inch telescope.

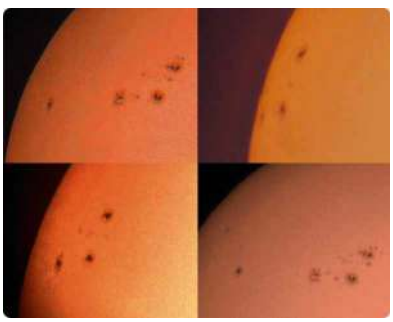
If I had been at home I would have used my much smaller telescopes, which would have been quite adequate. It just shows that you don't need too much technical or expensive equipment, or even expertise, to achieve good results. I'm really pleased with this and the simplicity of it. Anybody can do it, just give it a try!!

Sue Silver, Sheffield

What a fantastic image, Sue, the two clair-obscur effects really stand out. Well done! ***– Ed.***

Tweet

Peter Lewis
@PeterLewis55 • Apr 21
Development of massive sunspots that have appeared since Easter Sunday (numbered AR2993-6). Inspired by @Avertedvision @skyatnightmag @StormHour @ThePhotoHour @VirtualAstro

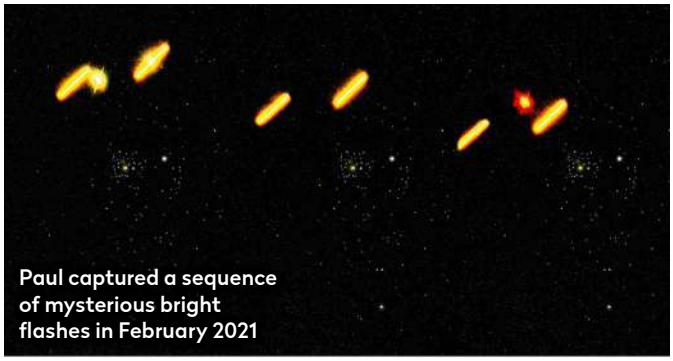


Felton captured a grouping of planets, along with a crescent Moon, over New York in March 2022
Venus
Mars
Saturn
Waning crescent Moon

Manhattan morning

Towards the end of March this year I took an icy walk in Manhattan, back and forth from 2nd Avenue to the East River in the two hours before dawn, stalking the triangle of planets in the constellation of Capricorn, the Sea Goat. On the other side of the constellation, the 28th-day waning crescent Moon was to slowly process across the planets and then slide below them towards Aquarius a few nights later. I was reminded of how, for four days after Hurricane Sandy in 2012, here in New York you could see every star in the sky before electricity was restored.

Felton Davis, 2nd Avenue Star Watchers, New York City, US



Paul captured a sequence of mysterious bright flashes in February 2021

Bright ashes

Do you have any idea what these bright streaks in my image are? I've recorded meteors many times and these leave a bright, thin trail as they streak across the sky. But these bright objects startled me when they flashed by NGC 2362 on 10 February 2021. They were accompanied by additional 'explosive' flashes, two of which are reproduced here. As I was filming I caught the whole sequence. Could they be fireballs?

Paul Sparham, via email

Thanks for getting in touch, Paul. The bright flashes in your image look a lot like sunlight glinting off two satellites. ***– Ed.***

Dark matters

Regarding the article 'Pioneers of dark matter' (May 2022), shouldn't the scientific community resolve this matter? If the proposers cannot prove it exists and the opponents cannot 'prove the negative', that it does not exist, then there's a stalemate. Milgrom, who proposes the effect is a function of gravity at the edges of galaxies, should be accepted. That will bring an end to the speculation that dark matter exists. At least Milgrom has proof, using gravity, and this will surely add to our understanding of this phenomenon; even if measurement is impracticable due to distance.

Stuart Hunter, via email

Moon lighting

This may seem a silly question from a fully grown adult, but I'm struggling to explain to my three-year-old daughter, so here we go... why can we see a full Moon? If the Moon has to be on the other side of Earth to the Sun for us to see a full ▸

ON FACEBOOK

WE ASKED: What is your favourite astronomy fact?

Carol Miller 1,300 Earths could fit into Jupiter. This fact blows my mind and it's something I regularly tell others when pointing out Jupiter in the night sky.

Austin Monks The Moon is 400 times smaller than the Sun, but also 400 times closer to us, which makes them both appear equal in size in the sky (most of the time). This allows us to have stunning solar eclipses complete with the Sun's corona.

Steven Johnson Venus's day is longer than its year.

Mihai Saiph The further we look into deep space, the younger we see the Universe.

Debz Townsend Jupiter is the fastest spinning planet in the Solar System and it has rings!

Stephen Webber Saturn would float in the bath.

Alex James There are more stars in the Universe than grains of sand on Earth.

Martin Bailey The rocks in Saturn's rings are so close together that you could walk on them like stepping stones.

SCOPE DOCTOR

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With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I want to attach a motorised RA drive to my Sky-Watcher EQ5 mount, but will I still be able to use the manual fine-adjustment controls after the motor drive has been installed?

TONY GRETTON

▲ Adding motor drives to an EQ5 mount still allows manual control

The Sky-Watcher EQ5 is an equatorial mount with two large, knurled, plastic knobs to make fine adjustments to the RA (Right Ascension) and dec. (declination) axes by hand. The mount can be upgraded with either a single or dual axis motor drive and a choice of either a basic or more advanced hand controller, the latter including an ST4 interface for auto-guiding.

Installing the Sky-Watcher motor drives doesn't remove the ability to adjust the pointing of the telescope manually with the fine control knobs, as the upgrade includes knurled knobs that control slipping clutches mounted on the original drive shaft. When the clutch knob is slackened off, the motor drive is disengaged and maunal control is enabled.

A rough pointing is carried out by loosening the main RA and dec. clutches and manually pushing the telescope to the correct position. Fine adjustment is made by re-tightening the main clutches and using the hand controller's direction buttons to centre the chosen object in the field of view.

Steve's top tip

What is a dew shield?

Dew shields are cylindrical extensions fitted to the front of refractors. They can be added to Schmidt-Cassegrains, by using a piece of camping mat cut to size and wrapped around the scope tube's front. Dew shields stop stray light entering the light path from oblique angles and reduce the formation of dew.

Telescopes reach equilibrium with the ambient temperature through convection, but after that the glass elements continue to cool through radiation, causing dew. Trapping a pocket of air in front of the primary lens reduces the radiation rate and the dew shield restricts the direction in which it takes place.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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Instagram

anas.albounni • 15 Apr 2022

With the rise of the first day of Ramadan, 2 April, an early morning shot of the Milky Way from @eao_ae with my gear in the foreground. Nikon D810a, Nikon 12–24 2.8, 10 subs, 15" each, ISO 6400, on a tripod, stacked in Sequator, processed in Photoshop. @bbcskyatnightmag

▸ Moon, why doesn't Earth's shadow block out the light. And how does the Sun's light reach the Moon with Earth in the way? I'm hoping I'm not the only person to think this and hope, maybe, other readers must have thought this at some point.
Adam Rulewski, via email

That's a great question Adam. We see a full Moon when the Sun, Earth and Moon are in a line because the Moon's orbit is angled about 5° from being lined up with the ecliptic (Earth's orbit of the Sun). At the distances involved, that 5° angle is enough to allow sunlight to pass Earth and reach the Moon. ***– Ed.***

CORRECTIONS

• In the picture of M65 and M66 in 'From city lights to deep space' (April 2022 issue, page 30), the caption incorrectly said the two galaxies are approximately 35 lightyears apart. M65 and M66 are in fact 160,000 lightyears apart and around 35 million lightyears away.

• In the star chart of Coma Berenices in 'From city lights to deep space' (April 2022 issue, page 32), NGC 4564 should have been labelled NGC 4565.

• In the caption to the image of an astronaut collecting rock samples on the lunar surface in 'Apollo 16' (April 2022 issue, page 35), Charles Duke was incorrectly named as Charles Young.

• In the caption to the extravehicular activity map in 'Apollo 16' (April 2022 issue, page 37), Charles Duke was incorrectly named as George Duke.

SOCIETY IN FOCUS

Swindon Stargazers was founded in 2009, the International Year of Astronomy, by Peter Struve, a descendant of the famous family of astronomers such as Friedrich Georg Wilhelm von Struve, who is best known for his study of double stars, and after whom many are named.

The club exists to promote the hobby of astronomy and we meet once a month in our local village hall, where speakers give talks on aspects of observational and scholarly astronomy.

The club conducts many outreach activities, such as working with uniformed groups on their astronomy badges, and with groups such as the National Trust at Avebury. We've also worked with Wiltshire Wildlife Trust at its Blakehill Farm Nature Reserve, Women's Institutes, libraries and schools, and with Marlborough Town Council for the Marlborough Dark Skies Festival, where we have recently organised our 'Stargazing on the common' event.

▲ Swindon Stargazers at Marlborough Dark Skies Fest in October 2021

Members also support a Swindon U3A Astronomy Group.

The club has a number of telescopes that can be loaned to members, and practical astronomy is actively encouraged. Members also regularly attend star parties around the country.

The club is a member of the Federation of Astronomical Societies (FAS) and is run for the benefit of its members to support and encourage their interest in astronomy.
Robin Wilkey, Chair, Swindon Stargazers
▸ www.swindonstargazers.com

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Live Space flight photography

Rook Lane Chapel, Frome, Somerset, 25 June, 7:30pm

Photographer John Angerson, who had unprecedented access to NASA's 1996 Space Shuttle STS-72 mission, talks about his work photographing the intense training and documenting the close friendships of the six astronauts. Tickets are £10. **photofrome.org/talks**

Live & Online Life in the Universe

Museum of London, 1 June, 6pm

Gresham Professor of Astronomy Katherine Blundell's lecture explores what ingredients are needed to sustain life on planets beyond Earth. Book to see live or watch online: **sciencelive.net/event/1314**

Live STEMTots

Cambridge Science Centre, 10 June, 9:15am

A special session for accompanied pre-schoolers to learn about the Solar System, including making a mobile, designing a planet and building a rocket. Costs £3.28 per adult with a child. **bit.ly/3vxG9wN**

Online High Energy Astrophysics

Starts 15 June

How does a black hole form? What's going on in active galaxies? How do we explain gamma ray bursts? This five-month Astrophysics Research Institute course covers the most powerful phenomena in the cosmos. The course costs £225. Sign up by 31 May. **astronomy.ac.uk/info/energy**

NASA, BECCY LANE, ANTHONY HOLLOWAY, ANDREW BROOKS, SCOT SALT

PICK OF THE MONTH

▲ Enjoy the new facilities at Jodrell Bank Observatory, Britain's birthplace of radio astronomy

LIVE First Light Pavilion

Jodrell Bank Observatory, Cheshire, from 4 June

Jodrell Bank's £21.1m First Light Pavilion opens this month, a brand-new interactive exhibition space telling the human stories behind the birthplace of British radio astronomy. The striking grass-covered building also features a state-of-the-art immersive Space Dome planetarium, guided tours of the groundbreaking UNESCO World Heritage Site and a large new café alongside the existing displays, famous clockwork orrery and, of course, the 76m-wide Lovell Telescope. Watch out for details of a summer of public events planned for the new pavilion. Adults £12, children £8. **www.jodrellbank.net/visit**

Live Mars exploration talk

Bredhurst Village Hall, Gillingham, 24 June, 8pm

Professor David Southwood, former director of science and robotic exploration at the European Space Agency, reveals the 'trials, tribulations and triumphs' of exploring Mars. Followed by an observing session. **www.midkentastro.org.uk**

Live Ayrshire monthly meet-ups

The Kyle Academy, Ayr, 27 June, 7pm

Every fourth Monday of each month the folks at Ayrshire Astronomical Society meet up, usually for a presentation by members or guest speakers. All local dark-sky fans are welcome. First meeting is free. **www.ayrastro.com**

Live Jewels of the Universe

Kielder Observatory, Northumberland, 29 June, 9pm

Kielder's science team share their passion for astronomy in this special evening. Be guided around the planets, galaxies and Moon, spot noctilucent clouds and get to hold space rocks. Tickets are £25. **kielderobservatory.org/our-events**

UNISTELLAR
THE UNIVERSE AWAITS
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M51 - WHIRPOOL GALAXY
M57 - RING NEBULA
Nikon EYEPIECE TECHNOLOGY
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FIELD OF VIEW

A landmark of space exploration

Andrew Grasemann recalls a visit to Baikonur Cosmodrome with Patrick Moore

◄ 1. In 1991 Patrick Moore was filmed for *The Sky at Night* from Baikonur Cosmodrome.

2. A view of a Soyuz capsule that was being assembled...

3. ...and of Progress M-7 as it launched with supplies to Mir

◄ 4. Up-close to a giant booster rocket for the Buran shuttle programme.

5. The Cosmonaut Hotel where Andrew stayed during his visit to Baikonur

Back in March 1991, I had the good fortune to travel with *The Sky at Night* team to Baikonur Cosmodrome in Kazakhstan to see its rocket assembly and view a launch of a supply ship to the Mir Space Station.

Sky at Night producer Pieter Morpurgo had the idea of visiting Baikonur and got approval from the Soviet space authorities for the trip. To spread the cost, the trip was organised in collaboration with Explorers Tours – a specialist in astronomy trips – and a dozen space enthusiasts were offered the chance to go on this unique, once-in-a-lifetime experience. I was among the lucky 12 to be selected for the trip, which also included Dr John Mason, a regular guest on *The Sky at Night*, as well as Patrick Moore himself.

The group flew to Moscow and we were then taken in the dead of night to another airfield outside the city, to be flown 2,500km in an Antonov An-72 transport plane to Baikonur in Kazakhstan. As we arrived, we were greeted by a very cold, bleak snow-covered landscape. We had a police escort from the airfield to the Baikonur Cosmodrome, where we were shown the launch pad used by Vostok 1 with Uri Gagarin, the first human in space.

We then travelled to the Assembly Complex. Initially, I was underwhelmed when I saw some dilapidated warehouse-type buildings, but my breath was taken away when we entered the first building and saw a Proton rocket lying on the floor.

The scientists we saw were thrilled to be able to talk about their work and were very open with us. We were taken to see the Buran shuttle, which was almost identical to the US Space Shuttle. It was a thrill to be able to see it close up.

We were then taken to the Soyuz capsule assembly building, and were shown the capsule which was being readied for the Juno mission – which British astronaut Helen Sharman would be launched in.

In the museum on the site, we entered the Lunar Explorations room, where Patrick saw in one of the display cases 'The Patrick Moore Moon Globe'. The curator of the museum quickly opened the case and got Patrick to sign the base of the globe in felt pen. Patrick was then invited to sign the visitors' book, containing all the names of dignitaries who had visited.

The day's finale was seeing a launch of Progress M-7, a supply ship for the Mir Space Station. Watching it from a 3km distance and the viewing stand normally reserved for dignitaries and leaders, we had a good vantage point. Our overnight stay was in the same hotel used by the cosmonauts before their flights.

Being a space enthusiast from my childhood and following the Apollo missions, it was a real highlight of my life to get such close-up views of the Soviet launch facilities and assembly, and I even featured in the broadcast programme saying why I was on the trip.

Andrew Grasemann is a lifelong amateur astronomer and space enthusiast, and a member of Bristol Astronomical Society (BAS)

ANDREW GRASEMANN X 5

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BBC Sky at Night MAGAZINE

The summer nights may be shorter, but it doesn't mean you have to put a stop to your observations of the fascinating objects that fill the sky

Balmy nights of brilliant sights

Astronomer **Will Gater** picks out the celestial targets that will keep both observers and imagers enchanted on clear, June nights

When I was getting into astronomy it was always said that, as summer arrives, the lighter nights make observing sessions rather pointless. What I eventually learnt is that while chasing the dimmest faint fuzzies at the eyepiece might be out of the question in June, the warm evenings can still be a time when treasured celestial memories are made. There's certainly no reason to leave the telescope or binoculars gathering dust this month, with some fine star clusters, noctilucent clouds, planetary alignments and more to be seen. In this article we've picked out a selection of phenomena that will hopefully provide some satisfying observing and imaging challenges during the nights of June. And while our list is tailored slightly more to the interests of an intermediate-level astronomer with photographic kit to hand, there are some great beginner targets scattered among them.

Will Gater is an astronomy journalist and science presenter. His latest book, *The Mysteries of the Universe*, is published by DK

The Beehive Cluster

We begin our journey around June's night skies with a goodbye of sorts, looking at a spring target that's sinking into the west now that summer's here. On the night of 1 June you'll find the beautiful Beehive Cluster, M44, dropping low on the west-northwest horizon as midnight approaches. It's the perfect observing target for 10x50 binoculars, or similar, which will show the numerous glittering stars of the open cluster scattered around a patch of sky that's roughly a degree across. A few nights later, on 4 June, the crescent Moon lies about 6.5° from the Beehive Cluster. With earthshine – when light scattered off Earth lights up the Moon's night side – showing up at this lunar phase, the arrangement could make for some striking nightscape-style astrophotography compositions.►

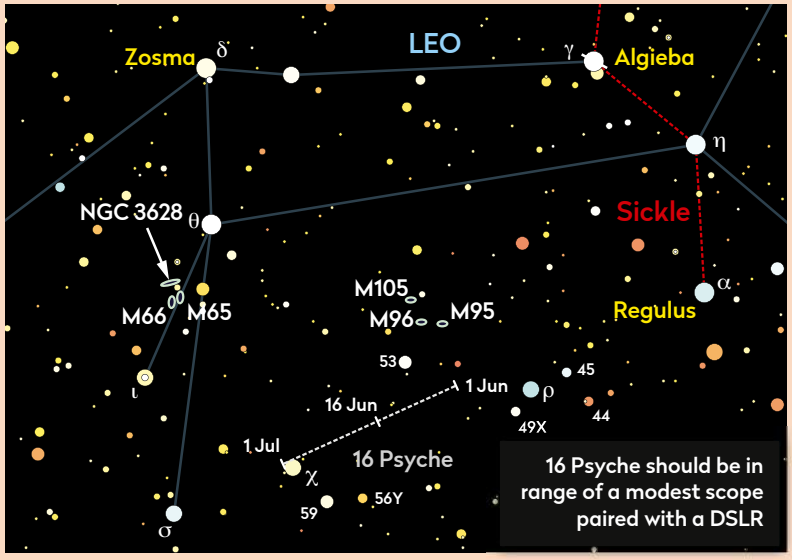
The Beehive Cluster is thought to be home to 1,000 stars

WILL GATER X 2, M-GUCCI/ISTOCK/GETTY IMAGES

ASTROPHOTO HIGHLIGHT

Asteroid Psyche

Our first astrophoto highlight is a target that's ideal if your deep-sky imaging rig is getting a little less use now the lighter evenings are upon us. Asteroid 16 Psyche orbits within the main asteroid belt and it is going to be visited by a NASA spacecraft that's due to launch in August. The mission's namesake will be positioned in the constellation of Leo, the Lion, in June and, at around 12th magnitude, should be in range of a modest telescope and DSLR or CCD camera combo. Around 1 and 2 June the asteroid is sitting not too far from some of the brighter galaxies in Leo. With a bit of clever framing, using a wide-field setup and some stacked long-ish exposures, it may be possible to capture the point of light that is Psyche in the same field of view as the likes of M95 and M96.



▲ The first few days of June offer the best chances of seeing the Coma Star Cluster

Coma Star Cluster

The Coma Star Cluster is in the L-shaped constellation of Coma Berenices (Berenice's Hair) and it lies about halfway between Denebola (Beta (β) Leonis) and Cor Caroli (Alpha (α) Canum Venaticorum). The cluster can be tricky to see from light-polluted locations, but it can be viewed with the naked-eye from a dark suburban spot. It looks superb in a pair of 10x50 binoculars and is dominated by 4th-, 5th- and 6th-magnitude stars. The best time to view the cluster will be in the days leading up to 5 June, after which the Moon will interfere. Find it about 30–35° above due west around 01:30 BST (00:30 UT).

▲ Find M53 by following the signpost formed by Coma Berenices

Messier 53

We don't have to go far to find the next target. It's a telescopic object suited to a larger scope of 8-inches (200mm) or more: the globular cluster M53. It also sits in Coma Berenices, about 14° away from the Coma Star Cluster. If you intend to star hop to M53, first identify the extended 'L' shape of Coma Berenices (see the all-sky chart in the 'Sky Guide' on p50 if you need a refresher). Then direct your finderscope towards the 4th-magnitude star Alpha (α) Comae Berenices at the other end of the 'L' from the Coma Star Cluster. From here head northeast by about a degree and M53 should fit nicely in the field of view of an eyepiece giving around 70x to 80x magnification.

▲ Scorpius crawls over the southern horizon at midnight during late June

Scorpius on the horizon

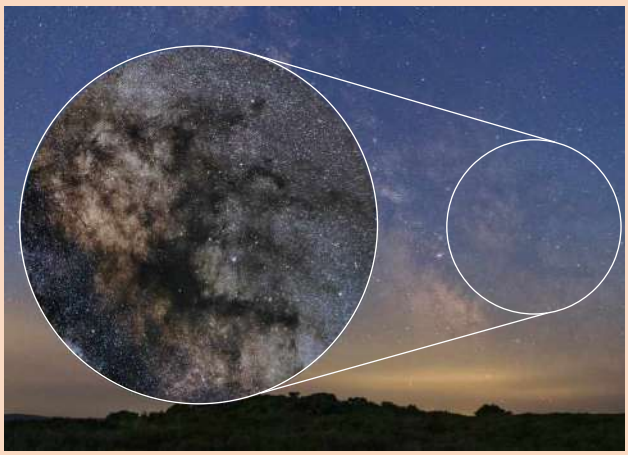
If you're observing or imaging from a location with a clear southern horizon, look towards the constellation of Scorpius, the Scorpion. This region of the sky is often hidden by the skylines of towns and cities, so it's a good one to look out for if you're heading away from home. From the UK, the constellation will be spanning the meridian around midnight in late June, when the Moon is out of the way. Its low altitude makes it suitable for wide-field nightscapes over distant horizons, with the bright stars comprising the pincers and head of the Scorpion balanced against rich Milky Way star fields nearby.

WILL GATER X 4, CHARTS BY PETE LAWRENCE

ASTROPHOTO HIGHLIGHT

The Prancing Horse Nebula

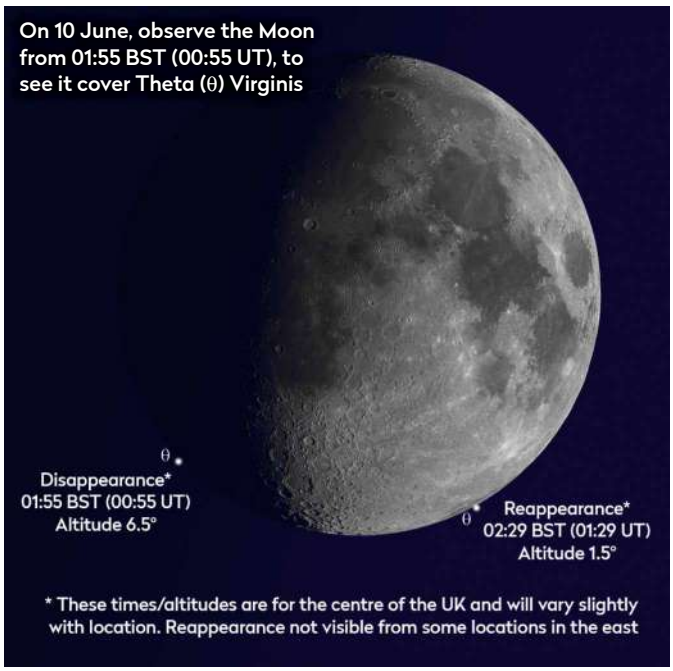
Move (very slightly) to the east from Scorpius and you can turn your attention towards the bright star fields of the Milky Way that lie next door in Ophiuchus, the Serpent-Bearer. This region is close to the core of the Milky Way and the dense swathes of stars here are crossed by numerous dark nebulae, interstellar clouds of gas and dust within the Galaxy. One, the so-called Prancing Horse Nebula, is an especially striking astrophotography target, suited to both nightscape and deep wide-field imaging. In June, with little real darkness around, you might like to try the former. The nebula is easy to find as it's mostly contained within a triangle made by the very bright stars Antares (Alpha (α) Scorpii), Lambda (λ) Sagittarii and Eta (η) Ophiuchi.



▲ **The Prancing Horse Nebula is a worthwhile and rewarding subject for astrophotography in June**

Occultation of Theta Virginis by the Moon

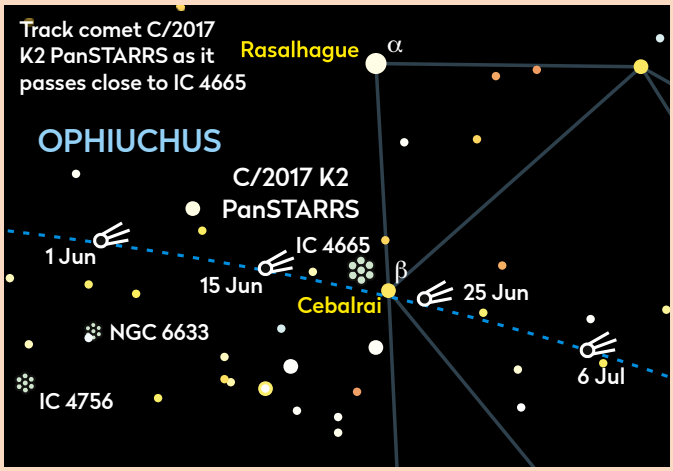
This month we have a chance to see the lunar disc hide a relatively bright star during an event known as an 'occultation'. Though professional astronomers often use occultations by Solar System objects to refine their understanding of the orbits and shapes of distant bodies, this event is more of an interesting telescopic spectacle than anything else. At around 02:00 BST (01:00 UT) on 10 June, the star Theta (θ) Virginis will be covered by the dark southwest limb of the 75%-illuminated gibbous Moon from the UK. Use planetarium software to confirm your exact local circumstances and aim to be observing around five minutes beforehand so you can catch sight of the star before it suddenly disappears from view.

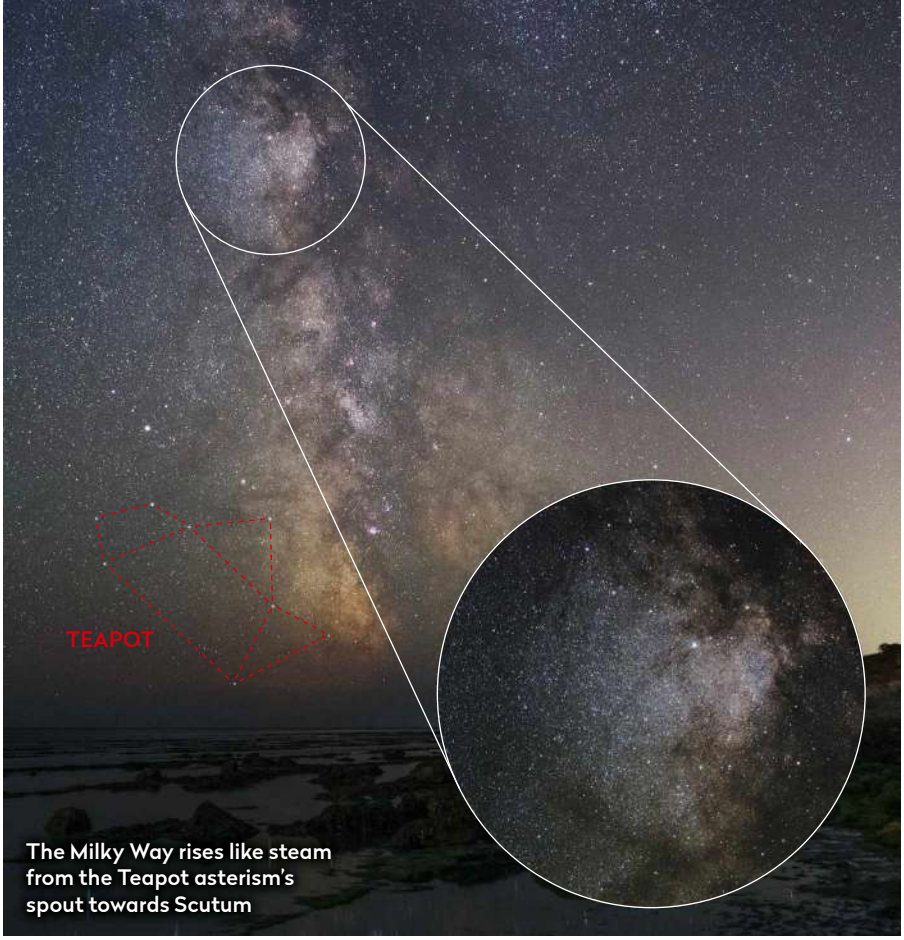

On 10 June, observe the Moon from 01:55 BST (00:55 UT), to see it cover Theta (θ) Virginis
θ
Disappearance*
01:55 BST (00:55 UT)
Altitude 6.5°
θ
Reappearance*
02:29 BST (01:29 UT)
Altitude 1.5°
* These times/altitudes are for the centre of the UK and will vary slightly with location. Reappearance not visible from some locations in the east

ASTROPHOTO HIGHLIGHT

C/2017 K2 PanSTARRS near IC 4665

The comet C/2017 K2 PanSTARRS was discovered by the PanSTARRS project in 2017. It's now heading into the inner Solar System on a hyperbolic orbit. This month the comet is relatively high in the UK sky and will be passing through the constellation of Ophiuchus. At the start of June it's about halfway between the stars Zeta (ζ) Aquilae and Beta (β) Ophiuchi, and on the nights of 19/20 and 20/21 June it will pass less than a degree from the open star cluster IC 4665, in Ophiuchus. This should provide a great opportunity for wide-field imaging with either a long camera lens or wide-field telescope. The Moon rises at about 01:25 BST (00:25 UT) on the 19/20 June, so capture your exposures before its light washes out the sky. The next night the Moon is out of the way until about 01:40 BST (00:40 UT), when it pops above the horizon. ▸





The Milky Way rises like steam from the Teapot asterism's spout towards Scutum

The Scutum Star Cloud

Look due south around 02:00 BST (01:00 UT) this month and, at least from the southern parts of the UK, you'll be able to glimpse the Milky Way rising from the horizon. Low down in the Milky Way sit the bright stars that make up the 'Teapot' asterism in Sagittarius, the Archer, and above them lies the less prominent constellation of Scutum, the Shield – its most striking feature being the famous star 'cloud', which dominates its northern half. The Cloud is really a bright patch of Milky Way star fields that stands out from the band of the Galaxy surrounding it. It's visible from dark suburban locations if the sky transparency is good, and it makes a wonderful sight in binoculars if you're far enough away from light pollution.

Fit M32 and M110 in the field of view with the Andromeda Galaxy

Andromeda's satellite galaxies

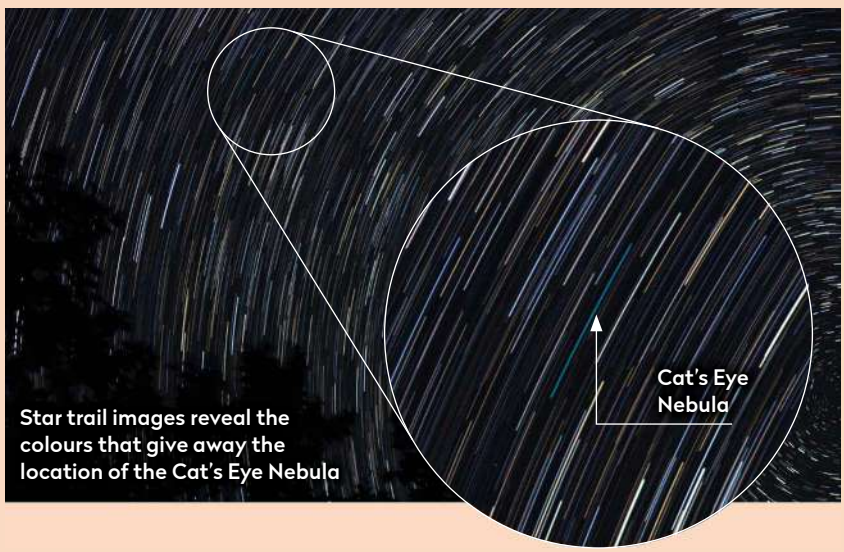
Many of us have marvelled at the Andromeda Galaxy, but have you ever looked for its two most prominent satellite galaxies? M32 and M110 appear close to the centre of Andromeda and are good targets for a medium- or large-aperture telescope. You'll find the Andromeda Galaxy sitting about 30° above the northeast horizon around 01:30 BST (00:30 UT) towards the end of June. A nice way to view M32 and M110 is to select an eyepiece that produces a field of view about 2° across, as this allows both targets to be seen at the same time, with Andromeda's disc cutting in between.

WILL GATER X 5, CHART BY PETE LAWRENCE

ASTROPHOTO HIGHLIGHT

The Cat's Eye Nebula

What's the simplest astrophotography setup that you can image a planetary nebula with? How about a DSLR camera and a medium focal-length lens on a static tripod? If that sounds intriguing, here's an imaging challenge to try this month. The Cat's Eye Nebula is a planetary nebula around 3,000 lightyears away towards the constellation of Draco, the Dragon. It's just about bright enough that, if you have reasonably dark skies, you can pick up signs of it with the kit described above. For our image (below) we used a 50mm lens. Now, you're not going to capture any detail in the nebula at that focal length, but you will be able to pick it out as a tiny greenish point of light. To be in with the best chance of detecting the nebula, try a star trail-style shot, in which you take multiple long-ish exposures – 30-seconds at least – and then stack them together with your preferred star trail-creation software. What you'll find is that the Cat's Eye Nebula stands out conspicuously from the stars as a greenish-blue arc.



Star trail images reveal the colours that give away the location of the Cat's Eye Nebula

Noctilucent clouds

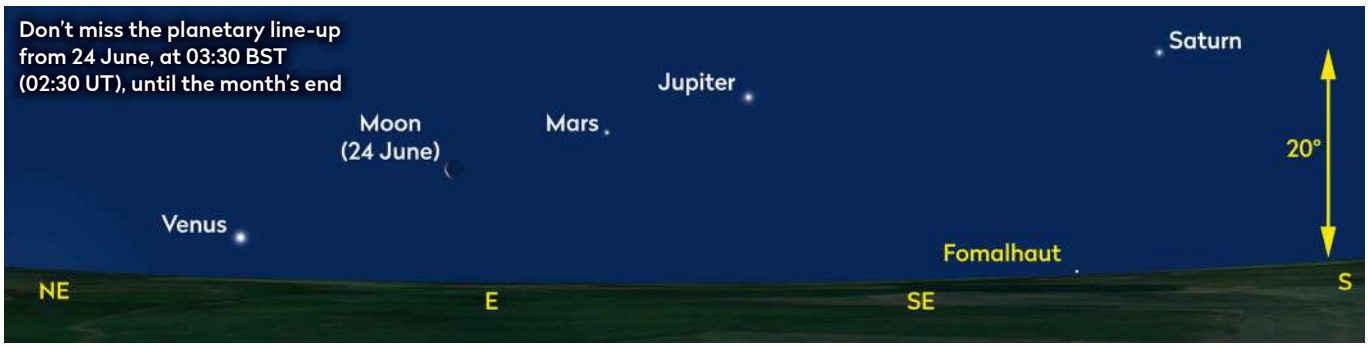
As early June comes around we should start seeing noctilucent clouds (NLCs). These clouds of ice crystals in the mesosphere make wonderful targets for observing and imaging. Indeed, their always-different, always-changing shapes – as viewed against vibrant twilight skies – are particularly suited to time-lapse astrophotography. In the evening, look for them low on the northern horizon about an hour after the Sun has set. You're looking for thin wisps and tendrils of whitish-blue light, sometimes in snaking river-like forms, other times with wave patterns embedded in bright curtains of light. Binoculars are an effective way to visually monitor the motions within a display over the course of a minute or so.

▸ For more information and tips about spotting noctilucent cloud displays, see the 'Sky Guide' on page 47

Ice crystals in noctilucent clouds scatter the light shining on them

Predawn planets

At around 03:30 BST (02:30 UT), from 24 June to the end of the month, there will be a striking array of planets aligned across the sky. If you have a clear view, such as a sea horizon, to the east-northeast you may be able to see Venus sitting around 2° above the horizon. The display will stretch westwards from there, along the ecliptic, with Mars, Jupiter and Saturn visible too. A camera may be able to pick up the speck of Neptune as well. From 24 to 26 June, a thinning crescent Moon will be visible between Mars and Venus, which adds another captivating element to the show.



Don't miss the planetary line-up from 24 June, at 03:30 BST (02:30 UT), until the month's end

ASTROPHOTO HIGHLIGHT

Cloud trails around the Moon

The chances are that at some point this month clouds will interfere with our observing sessions, but that shouldn't stop us from trying out some astrophotography. One way I like to use passing clouds is in long-ish exposure nightscapes of the Moon. You can use an exposure of several seconds to allow the clouds to trail as they drift by the lunar disc. The challenge is to find an exposure and ISO setting (and the right gap in the clouds) that gives you detail on the Moon but also in the textures of the clouds. This requires some trial and error as you try to balance the exposure and the amount of blurring, which will depend on the exposure length and how fast the clouds are moving.

Clouds can add depth and dynamism to shots of the Moon

KPNO/NOIRLAB/NSF/AURA/P. MARENFELD

The dramatic skyscape above the WIYN 3.5m telescope, Kitt Peak, Arizona. Its operators deal with observation requests from astronomers the world over

What's it like to be a PROFESSIONAL ASTRONOMER?

Understanding the cosmos takes the work of thousands of people. **Ezzy Pearson** spoke to astronomers across the world to look at the many different roles that go into observing our Universe

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor

Back in the days of Galileo and Newton, an astronomer was a lone figure at a telescope eyepiece they had created themselves. They would go through the stars and planets one by one, taking handwritten notes and creating sketches, to build up a wealth of information over nights, years and decades.

As time moved on, bigger telescopes were built in prime locations on remote mountaintops and deserts. Astronomers would travel to use them, bringing specialist instruments and newly invented photographic equipment. This enabled them to capture the light of dozens of distant objects that were too faint to be seen with the naked eye. They could then carry these photographic plates home to analyse the objects. With so much data to look at, astronomers began employing mathematicians, known as computers, to do the work for them, while they pondered the meaning of what they saw.

Today, astronomy has grown into a collaborative process, with teams of specialists involved at every stage. Engineers craft new instruments while consortiums work on building huge telescopes. These observatories are often so out of the way, and so complex, that astronomers often don't use them themselves. Instead they put in requests for observations that are then made by dedicated operators. Once they've received their data, science teams then write papers, sharing their work with the community. The discoveries will then drive the push for new instruments and telescopes, beginning the cycle again.

We spoke to astronomy professionals from around the world to find out what goes in to every stage of understanding the Universe...

Putting ideas into action: Dr James Osborn tests his instruments on the 2.5m Isaac Newton Telescope in the Canary Islands

MATTHEW TOWNSON, TYLER BOURKE, SARAH ANTIER

Instrument builder

Dr James Osborn, Durham University

Creating professional astronomy hardware takes teams of dedicated instrumentation builders, like **James Osborn**

"I'm an instrument builder, at the concept-driven, prototype stage – looking at the next idea that is going to drive us to step up performance. My favourite part is the idea generation stage, where we get people together around a whiteboard and say: "This is the problem, how do we solve it?" We want 10 crazy ideas that we can shake around to get one usable idea.

"Ideas are easy, but actually making it is the hard bit. You need specialists to work out how to build that instrument, design it, develop it and test it.

"A lot of the troubleshooting during development is done by PhD students and post-doctoral researchers – they learn a lot from doing that. Then once the instrument is developed, we'll go to a big observatory and get the prototype instrument working on the sky. That's pretty hardcore, with 20-hour days, working away from home. During the day this involves getting things working, including software and hardware. Then, at night, we're actually seeing how it works on the sky.

"Once you've had a great idea and proved it works, it's no good if it just sits in a room, so a big part of my job is talking to people, getting them to take on the new technology, and working together to build bigger instruments in the future."

Telescope liaison

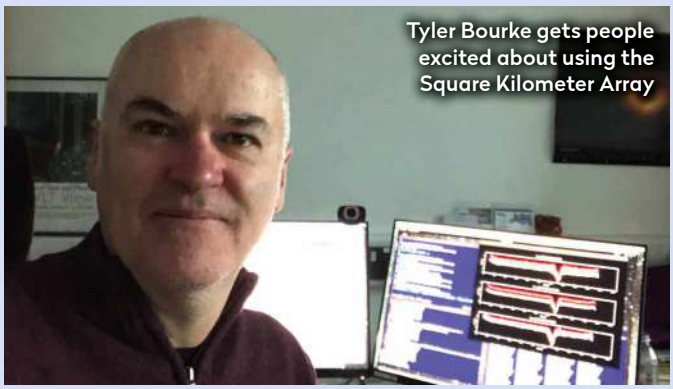
Dr Tyler Bourke, Project Scientist for the Square Kilometer Array

The Square Kilometer Array is a huge telescope being built across South Africa and Australia, and project scientists like **Tyler Bourke** ensure it will run to its fullest science potential

How do you help with building the SKA?
"The Square Kilometer Array (SKA) is just starting its construction – though we've been planning it for eight years – so a lot of what we're doing at present is discussing the design and building process through meetings. Too many meetings I would say!"

How do these discussions affect the SKA?
"I have technical meetings almost every day. I can't inform them on what sort of cabling should be used, but in terms of scientific needs – what wavelengths we need, what sort of spectrometers, how big the telescope has to be to achieve what we want – I might. This is a big science project and the highest level requirements are scientific, everything comes from that."

How are you planning for when the telescope is finished?
"These days, especially at the largest facilities, you don't go to the telescope. You put in a proposal and one day you get an email saying, 'Last night we observed your project'. We're going to have experienced, trained operators making the observations, but how will people submit proposals for observations? How will they look at the data? We discuss how the telescope will actually run.



Tyler Bourke gets people excited about using the Square Kilometer Array

"Finally, I also get people excited about the project. It's one thing to put information on a web page or in an email, but when you present it in a room, get people talking and planning, you keep it in the forefront of their minds. You can't put a value on that interaction."

Observation coordinator

Dr Sarah Antier, Observatoire de la Côte d'Azur and the Virgo Consortium

When a transient event – such as a supernova or black hole merger – happens, astronomers like **Sarah Antier** race to observe the event before it fades from view

"Violent phenomena – such as the collapse of massive stars or collisions of compact objects – release gravitational waves that are detectable by the interferometers like LIGO (Laser Interferometer Gravitational-Wave Observatory) and Virgo. Meanwhile, the material surrounding these events releases high-energy gamma rays, optical or near-infrared light. Fully observing these events can help us understand how matter behaves under nature's most extreme conditions, but that requires many observations from around the globe. That involves a lot of logistics and communication, but these observations can lead to wonderful discoveries for astrophysics, cosmology and fundamental physics.

"Alerts of gravitational wave detections... can arrive at any time"

"As soon as a gravitational wave is detected, I receive an alert. I lead the GRANDMA (the Global Rapid Advanced Network Devoted to Multi-messenger Addicts) collaboration – 85 amateurs and professionals, from 20 countries, that coordinate observations.

"Members of the collaboration take shifts waiting for these alerts. They can arrive at any time – at dinner, during my kid's bath, at a wedding – but I love the feeling of being on a treasure hunt when the alert first arrives! The first job is to check the 'sanity' of the alert – does it have an astrophysical origin? Meanwhile, observatories such as the TAROT telescope network (which I work with) image the source within seconds of the alert. The source will become weaker as the hours go by, so the first 48 hours after the alert is a race. Then we hand observations over to more sensitive telescopes like ESO, Hubble or JWST. Later, we use all the data to extract the physical properties of the source." ▸

Nicole Tan swaps over instruments in the Mount John Observatory....

Observational astronomer

Nicole Tan, PhD student at University of Canterbury

Nicole Tan spends her time requesting observations and then analysing the data to study trans-Neptunian objects on the outskirts of the Solar System

What does a typical day look like?
"I spend the majority of my time working on code and reading papers. Physically, that means a lot of sitting at a desk and staring at a computer screen! I'm also a teaching assistant for a few introductory astronomy courses. And of course, what is science without working with others – meetings with supervisors, meetings with collaborators – all avenues in which I get to chat about the field."

Do you ever get to go out?
"Observing trips and conferences are an important aspect of being an astronomer. Unfortunately, because I started my PhD during COVID-19, all my conferences have been online. Thankfully, the data for my project has already been collected, so COVID-19 didn't hinder that. Plus, most telescopes don't need you to be there to observe. But there's nothing like doing hands-on observing, so I'm glad that I recently got to go to Mount John Observatory here in New Zealand. It's located in a dark-sky reserve – I'm originally from Singapore and have only ever known light-polluted skies, so I got to see the southern sky for the first time."

What are the best parts of being an observational astronomer?
"I like the fact that astronomy, especially in the planetary sub-field, is interdisciplinary. I flit between computer science, physics, geology, chemistry, data science and statistics. The deeper I delve into the niche topic of my research, the more my understanding of these fields expands."

...and analyses exoplanet data

Is being an astronomer anything like what you expected?
"I did expect to spend more time observing. One thing I was surprised by is that posters are used so much as a regular presentation method. When I was in middle school presenting at the science fair, I never realised that I'd be doing the same thing at professional astronomy conferences. Of course, these ones are professionally printed, with significantly less hand-cut and glued elements!"

Queue observer

Eli Golub, WIYN observatory, Kitt Peak, Arizona

After astronomers have submitted their request for a particular observation, it's up to queue observers like **Eli Golub** to carry out the actual observations with the telescopes and instruments they operate

What do you get up to on a typical night?
"The job involves long shifts spent at the telescope, working in a control room alongside a telescope operator. Sometimes I like to joke that I'm a professional at sitting in one place for 17 hours, trying out new office chairs, but the job is so much more than that.

"I operate one of several instruments attached to the WIYN (Wisconsin-Indiana-Yale-NOIRLab) telescope. My instrument is NEID, a spectrometer that finds and characterises exoplanets. Part of my job is ensuring the starlight is correctly fed into NEID: a seemingly simple task that's surprisingly complex.

"Another part of my job is operating NEID's queue, which is a scheduling system that we use to plan our nights as efficiently as possible. It allows us to observe different stars for astronomers from all over the world in a single night."

Do you ever work during the day?
"I occasionally work day shifts where I get the opportunity to assist the engineers who are working to maintain and improve the telescope.

"I also have side-projects that I work on when I'm not observing on the summit. These can be anything from software projects in support of telescope operations to my own research into exoplanet science."

Are there any drawbacks to the job?
"The isolation can be pretty tough mentally. Most of these shifts are done solo, with only your thoughts, the stars, and the occasional spider to keep you company. It's not the worst thing, as it can be peaceful, but it certainly gets lonely from time to time."

Eli Golub uses the NEID instrument to observe different targets for astronomers

NICOLE TAN, NOIR LABS, KAZE WONG/CAMELS TEAM, DANIEL ANGLÉS-ALCÁZAR/CAMELS TEAM

The CAMELS project simulations reveal the web of matter throughout the cosmos

Simulation builders

Prof Daniel Anglés-Alcázar, the Flatiron Institute and University of Connecticut

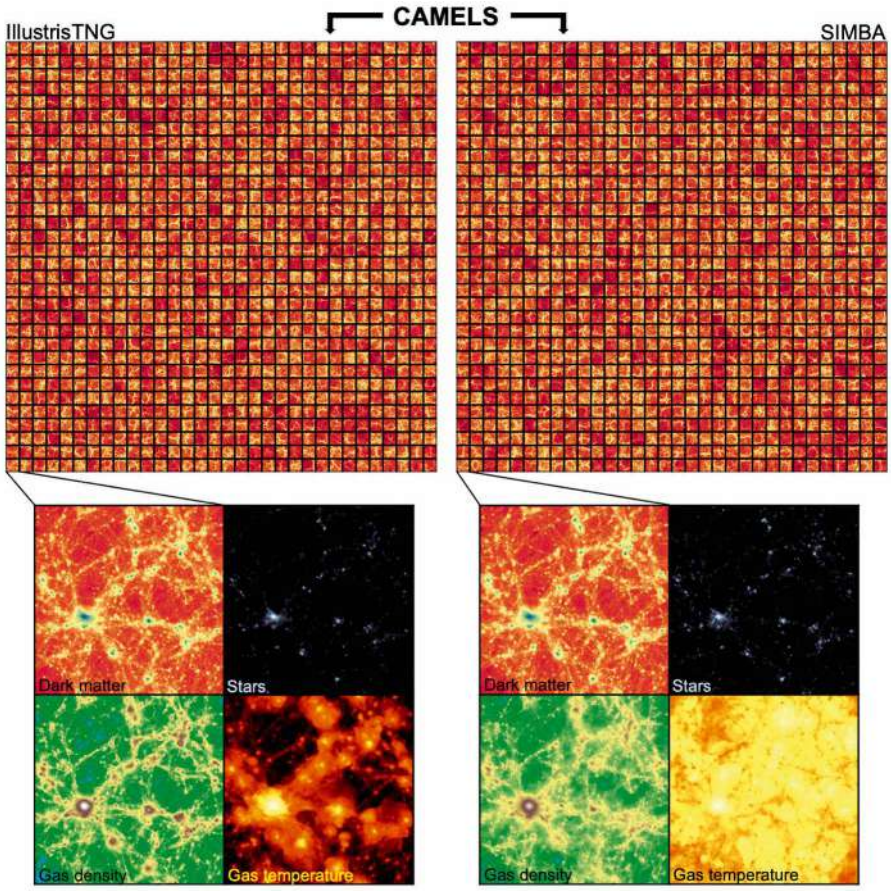
Daniel Anglés-Alcázar creates detailed simulations of the Universe around us with the CAMELS project

"I use computers to answer questions about how different astrophysical objects work. We use as much physics as we believe is important to produce 3D versions of simulated universes.

"First, we review the literature to evaluate the missing pieces of our understanding. Then we think about how to implement the physics we do already in the computer code.

"Once it is written, we have to check that the code is calculating what we actually meant and, more importantly, that the simulated universe it is producing is the correct one. We check that by comparing it to real observations. We convert our simulated galaxies into observable quantities to do an 'apples to apples' comparison. If they look completely different, that suggests important pieces of the physics are missing.

"The simulations I work on have many different elements. We have to keep track over 14 billion years of simulated time, so our codes have to make many calculations. Some projects may require 10 million hours of computing time. That would take over 1,000 years on a single computer, so we run the simulation over thousands of computers in a few months.



▲ **The CAMELS (Cosmology and Astrophysics with MachinE Learning Simulations) project team create thousands of simulations of the Universe and compare the results**

"The prospects for discovering something new from these simulations is huge because it's like having a lab the size of the Universe. It's very exciting to not know what's going to happen when you start a project – that element of surprise and discovery."

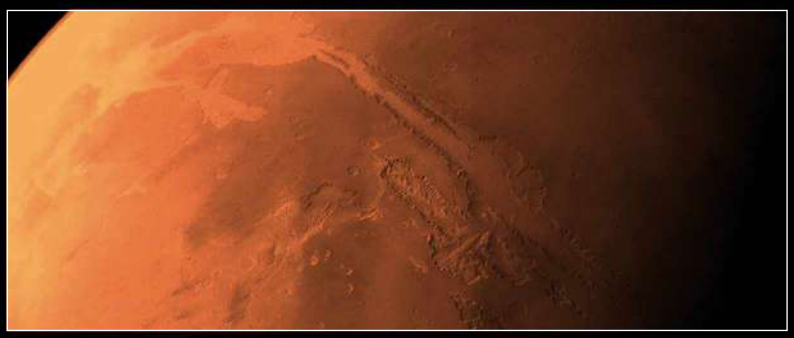
HOPE: one year at MARS

After 12 months spent observing the Martian atmosphere with its Hope probe, the United Arab Emirates has released a global map of the planet

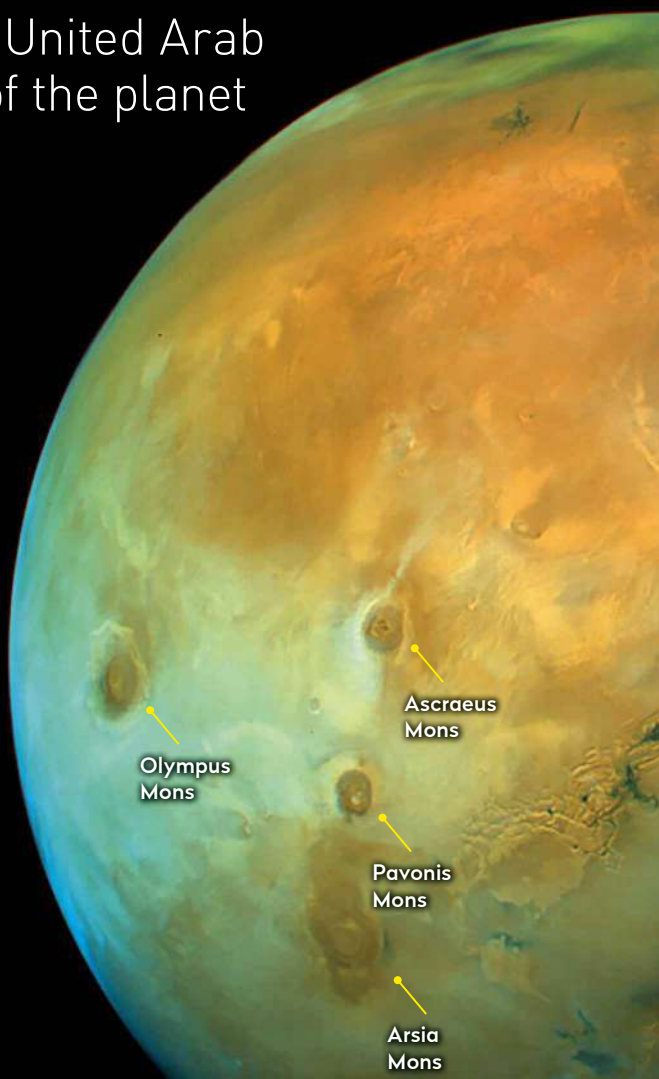
On 9 February 2021, the Hope Emirates Mars mission – the first interplanetary mission from the United Arab Emirates (UAE) – arrived at the Red Planet.

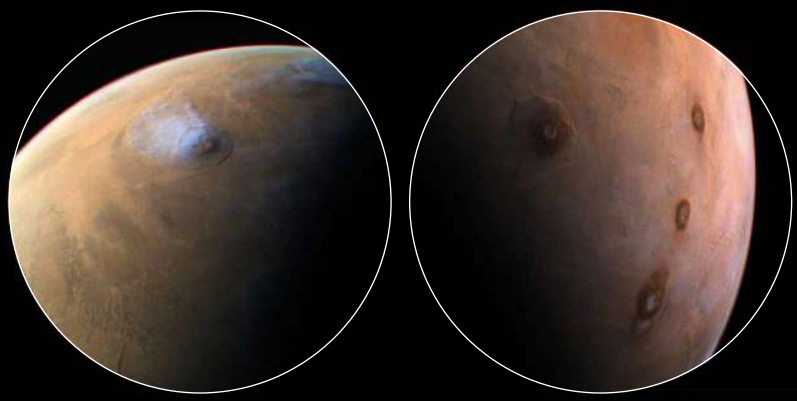
"The objective of the mission is to study the atmosphere's variability for a full Martian year – two Earth years," says Hessa Al Matroushi, science lead on Hope. "The maps we have from other missions to Mars have gaps in them. There would be measurements of the planet, say, two times a day and you'd have to predict what's happening in between – that's not accurate. Hope looks at the whole planet, surveying different layers of the atmosphere at different times of day, so we get full coverage. This is something that hasn't been done before with such accuracy."

Hope began science observations in May 2021 and the team has now released the first set of maps from its Atlas of Mars, tracking atmospheric and temperature changes during the day. This main science phase is set to cover one Martian year, giving a full picture of the Red Planet's atmosphere.



▲ **Valles Marineris** is a 4,000km-long canyon that reaches depths of 7km – about five times deeper than the Grand Canyon on Earth. It is a tectonic crack, created four billion years ago as the planet cooled.





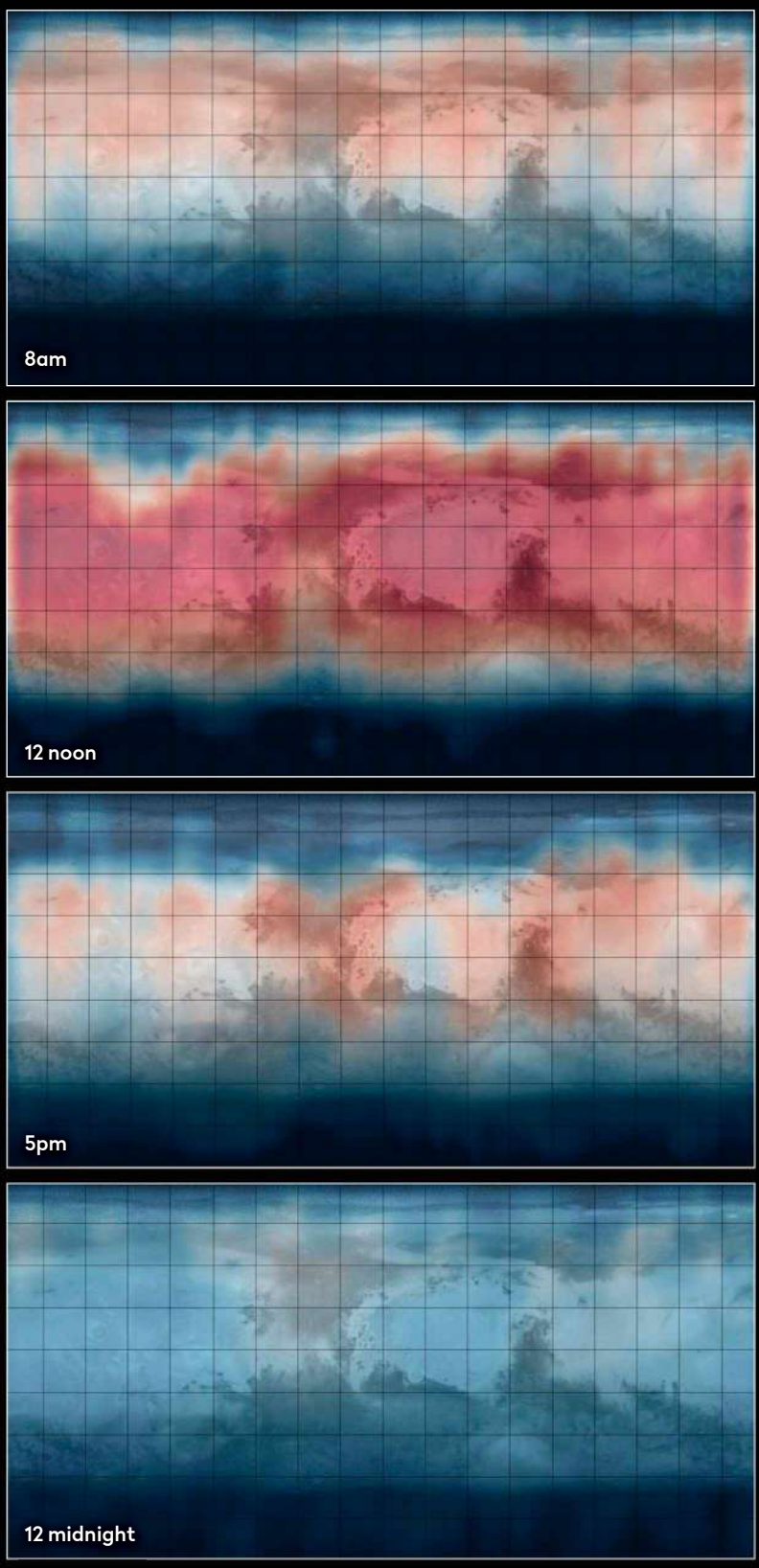
◄ The **Tharsis** region (pictured, left) covers a geological hotspot that has wbeen pushing the terrain upwards for billions of years, creating a 7km-high plateau. It is home to three of Mars's largest shield volcanoes: **Ascraeus Mons**, **Pavonis Mons** and **Arsia Mons** (from north to south). **Olympus Mons** (pictured, far left with clouds around the summit), the Solar System's largest volcano, lies to the west of Tharsis.

E_MIRATES MARS MISSION

A global view of Mars

"Although the mission was designed to study the atmosphere, the surface is also a very important component, and we need to understand how the two interact together," says Al Matroushi.

To do this, Hope conducted a 'capture' orbit, where it came very close to the planet, allowing it to take higher resolution images of the surface. It then moved out to its science orbit, which is wide to **view the whole globe at once** (below). "That was exciting because you can do a lot of surface science – you're able to see the rocks and the sand and study different regions, including **Valles Marineris** and **Tharsis**," says Al Matroushi.



Taking the temperature of the Red Planet

The Emirates Mars Infrared Spectrometer (EMIRS) looks at infrared light from Mars, generating heat maps of the entire planet at various points in the day. "We're looking into the globe's temperature and understanding its variability, as that impacts the climate," says Al Matroushi.

This set of **heat maps** (above) was created in July 2021, in the season of spring for the Red Planet's northern hemisphere, and it shows the change in temperature across the whole planet over an average day.

BBC Sky at Night MAGAZINE

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Will Gater

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WATCH ON DEMAND

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Steve Richards

We look at how a permanent observatory or fixed pier can benefit your observing by making sessions under the stars more productive.

Thursday 26 May, 7pm BST

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

JUNE 2022

THE RETURN OF NOCTILUCENT CLOUDS

Spot the high-altitude clouds on the edge of space

MARS AND JUPITER GET CLOSE

Catch an early morning meeting of the planets above the eastern horizon

ON THE TAIL OF A COMET

Track Comet C/2017 K2 PanSTARRS in Ophiuchus

JUHKU/ISTOCK/GETTY IMAGES

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- The Teapot asterism in the heart of Sagittarius
- 29 Amphitrite reaches opposition
- Perigee full Moon illusion

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

JUNE HIGHLIGHTS

Your guide to the night sky this month

All Month

Noctilucent cloud season begins from late May through to early August, making June an excellent month to look out for these high-altitude marvels.

Comet C/2017 K2 PanSTARRS continues to brighten and is well placed in northeast Ophiuchus.

Wednesday ▶ 1

Mag. –2.1 Jupiter appears 1.6° from mag. +0.7 Mars in the morning sky. Spot them low above the eastern horizon after 03:30 BST (02:30 UT).

◀ Thursday 9

The first of two opportunities this month to catch our 'Moonwatch' target, the crater Hortensius, occurs this evening. Hortensius lies near an impressive series of six domes known as the Hortensius Omega dome field. See page 52 for more.

Friday 10

Mag. +4.4 Theta (θ) Virginis is occulted by this morning's 74%-lit waxing gibbous Moon from 01:50 BST (00:50 UT) until 02:28 BST (01:28 UT) – times correct for the centre of the UK – ending just before both objects set.

Thursday 16

Mercury reaches greatest western elongation today, the planet appearing 23.2° west of the Sun in the morning sky.

Tuesday ▶ 21

At 10:14 BST (09:14 UT) the Sun reaches its most northerly position in the sky, a point in time called the Northern Hemisphere's summer or June solstice.

Family stargazing

The full Moon on 14 June, and fuller phases on following nights, appear huge when close to the horizon around moonrise due to the 'Moon illusion'. The Moon is in the correct position for this at 23:00 BST (22:00 UT) on the 14th. If clear, ask young observers to view it and then turn their back on it. Ask them to estimate how large it was using their thumb and forefinger at arm's length. Then turn them around to look at the Moon and get them to measure its real apparent diameter using a thumb and forefinger at arm's length. Chances are the first estimate is too big! **bbc.co.uk/cbeebies/shows/stargazing**

Sunday 26

There's a gorgeous view of mag. –3.8 Venus near a 7%-lit waning crescent Moon above the northeast horizon this morning from 03:00 BST (02:00 UT), mag. –0.2 Mercury following about 40 minutes later. The Moon lies 1.9° from Venus at 06:20 BST (05:20 UT).

Monday 27

Mag. –0.3 Mercury lies 3.3° from the centre of a slender 3%-lit waning crescent Moon this morning. Catch the pair low above the northeast horizon around 04:00 BST (03:00 UT).

PETE LAWRENCE X 7

Thursday 2

This is the first and best window of opportunity to look for our 'Deep-Sky Tour' targets in Ophiuchus, on page 56. The second window occurs in the last week of June, when nights are at their shortest for the year.

Friday 3

This evening the 'Star of the Month', Kornephoros (Beta (β) Herculis), reaches its highest altitude, due south around 01:00 BST (midnight UT). See page 53 for more.

Monday 6

Minor planet 29 Amphitrite reaches opposition. Shining at mag. +9.7, Amphitrite can be found low in Scorpius, the Scorpion in June.

This evening's almost first quarter Moon will reveal the clair-obscur effects known as the Lunar X and V.

Tuesday ▶ 14

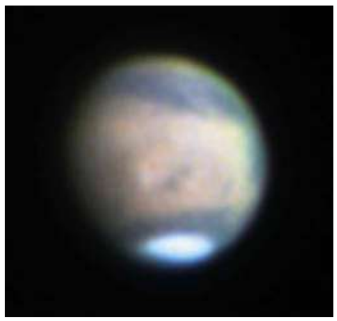
The full Moon at 12:52 BST (11:52 UT) occurs almost 12 hours before lunar perigee, when the Moon is closest to Earth in its orbit. Look out for this so-called 'supermoon' this morning to witness the Moon illusion.

◀ Sunday 19

This morning's 72%-lit waning gibbous Moon lies 8° east-southeast of mag. +0.7 Saturn. Catch them both above the southeast horizon around 02:00 BST (01:00 UT).

Wednesday 22

The 40%-lit waning crescent Moon lies 6.3° to the east of mag. –2.2 Jupiter in the morning sky.



◀ Thursday 23

This morning's 30%-lit waning crescent Moon sits 3.8° east of mag. +0.5 Mars.

◀ Thursday 30

Clear skies at the end of June gives those with a low southern horizon a view of the Teapot asterism at the heart of Sagittarius. Binoculars pointed north of the spout will reveal wonderful deep-sky objects such as the Lagoon Nebula, M8, and the Trifid Nebula, M20.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The top sights to observe or image this month

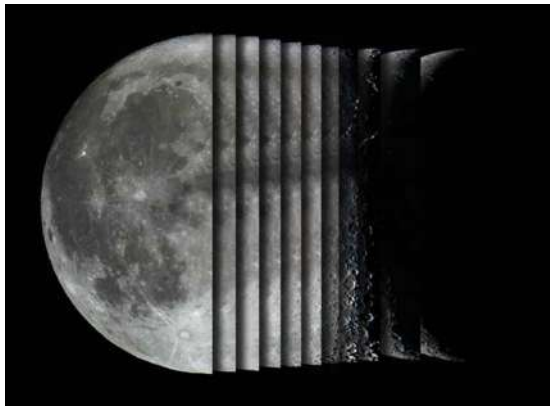
DON'T MISS

Perigee full Moon and the 'Moon illusion'

BEST TIME TO SEE: Evenings of 14–16 June

As the camera sees it and in reality, a low altitude full Moon is a similar size to one at a high altitude
To the naked eye, and mocked up here, a low altitude full Moon appears larger than it should due to the 'Moon illusion'

▲ **A composite image of a low- and high-altitude full Moon, top, dispels the Moon illusion**



▲ **The Moon's apparent diameter changes in its monthly cycle, as shown here in a comparison over 11 days from full Moon**

The lunar orbit is elliptical and over time this means the distance between Earth and the Moon varies. As you would expect, the apparent diameter of the Moon varies over its orbit because of this distance change. Apogee describes when the Moon is furthest from Earth, perigee when nearest. When it's closest, the Moon's apparent size is around 34 arcminutes, while at apogee the Moon's apparent size is around 30 arcminutes.

Apogee and perigee have no connection with lunar phase, the orbit cycle being out of sync with the phase cycle. A full Moon near perigee gains more attention than a regular full Moon because it appears larger and brighter than average, and has also become known by the popular term 'supermoon'. However, if you compare a perigee full Moon to the ones in previous and following months you probably wouldn't notice any difference.

Last month, the Moon was full at 05:15 BST (04:15 UT) on 16 May. Lunar perigee occurred at 16:27 BST (15:27 UT) on the 17th, meaning that was a perigee full Moon. The Moon had an apparent diameter of over 33' 40" on that date. In June, full Moon occurs at 12:52 BST (11:52 UT) on 14 June, perigee at 00:23 BST (23:23 UT) on 15/14 June, the Moon's apparent diameter reaching 33' 56", fractionally larger than May's. July's full Moon occurs on 13 July at 19:38 BST (18:38 UT), perigee on the 13th at 10:05 BST (09:05 UT), resulting in a maximum apparent diameter of 33' 57".

June and July's full Moons also offer the chance to see the 'Moon illusion'. This optical effect occurs when fuller phases of the Moon appear close to the horizon, after moonrise or before moonset. This month's full Moon sets around 04:10 BST (03:10 UT) on the 14th, as seen from the UK's centre. It can be seen rising again at 22:30 BST (21:30 UT) on the same date.

Catch it right and the illusion is powerful: it's hard to believe that the Moon you're looking at isn't larger than normal. In reality, the low Moon is a bit smaller than it appears when high up due to increased distance and atmospheric refraction.

If you see the full Moon illusion, take a photo using a 200mm or longer lens. When it has climbed higher, do the same thing. Using a layer-based editor, put both Moons side by side. This proves the 'giant' Moon is no larger than a regular one.

ALL PICTURES: PETE LAWRENCE

Noctilucent cloud season begins

BEST TIME TO SEE: 90–120 minutes after sunset or before sunrise

The season of noctilucent clouds (NLCs) is upon us once again, providing astronomical entertainment despite a reduced period of darkness at this time of year. NLCs are high-altitude ice clouds which form in a narrow layer, 82km up in the mesosphere. If present as the Sun dips below the horizon, they are able to reflect sunlight at their extreme altitude despite it being dark for us on the ground. As a consequence, NLCs appear to glow against the darker, deep twilight background during the summer months.

Typically seen 90–120 minutes after sunset above the northwest horizon, or at a similar time before sunrise above the northeast horizon, it's worth bearing in mind that NLCs don't always play by the rules. Also bear in mind that NLCs, if present, are typically low and can be easily hidden behind houses, trees and hills. Although it's generally the case that they appear low, they have been reported at high altitude too. As mentioned, they don't always play by the rules!

Observations of NLCs can be sent in to the British Astronomical Association's Aurora and Noctilucent Cloud Section

Typically NLCs track from northwest to northeast, disappearing in the middle of the night. However, extensive displays may persist all night long, with the bright region starting in the northwest, tracking through north and ending in the northeast. Under unusual circumstances NLCs have been seen away from their expected horizons, appearing low above the north and northeast even at sunset.

Taken all together, it's clear that observing NLCs is an important task. Documenting their appearance, location and apparent brightness is useful as long as you also record the date, time and location. NLCs are a photogenic phenomenon, but again it's important to make sure all the useful observational details are also recorded when you take photos of them.

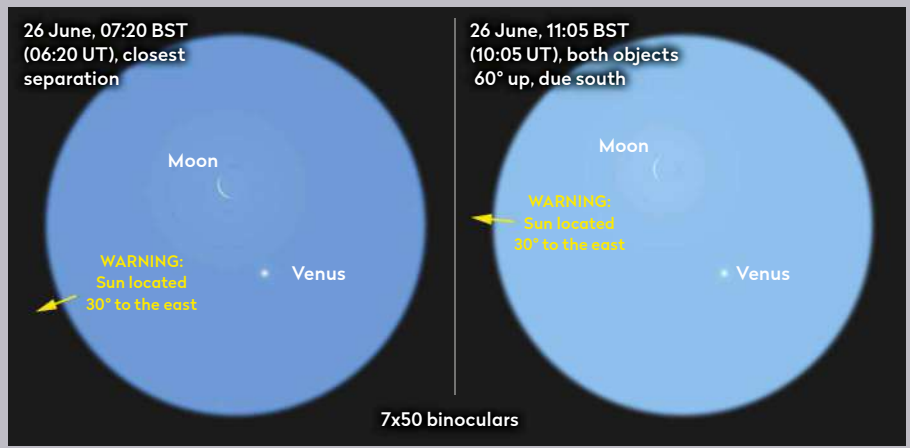
Morning Venus and the Moon

BEST TIME TO SEE: 26 June, from 50 minutes before sunrise

Venus is a morning planet in June (see page 48 for more details) and it also has a beautiful encounter with a 7%-lit waning crescent Moon on the morning of the 26th. On this date the pair will appear separated by 2.2° in the dawn twilight. However, as the day progresses the distance continues to reduce, albeit only slightly, which gives an opportunity for spotting Venus in daylight. (For more information about this see this month's 'Sky Guide Challenge' on page 55.)

Venus is a superb planet at any time, but even more so when it can be seen against a dark sky. Unfortunately, this won't be the case during June and the best that's on offer is to spot it against the deep blue of a late June dawn twilight. The presence of the Moon will enhance the scene and will add its own beauty by displaying earthshine, the effect which makes the night side of the Moon weakly visible.

The closest approach between Venus and the crescent Moon occurs just before 07:00 BST (06:00 UT), when both objects will be 1.9° apart, as measured from the centre of the Moon's disc. This occurs after the Sun has risen, providing a great opportunity to locate Venus during the day.

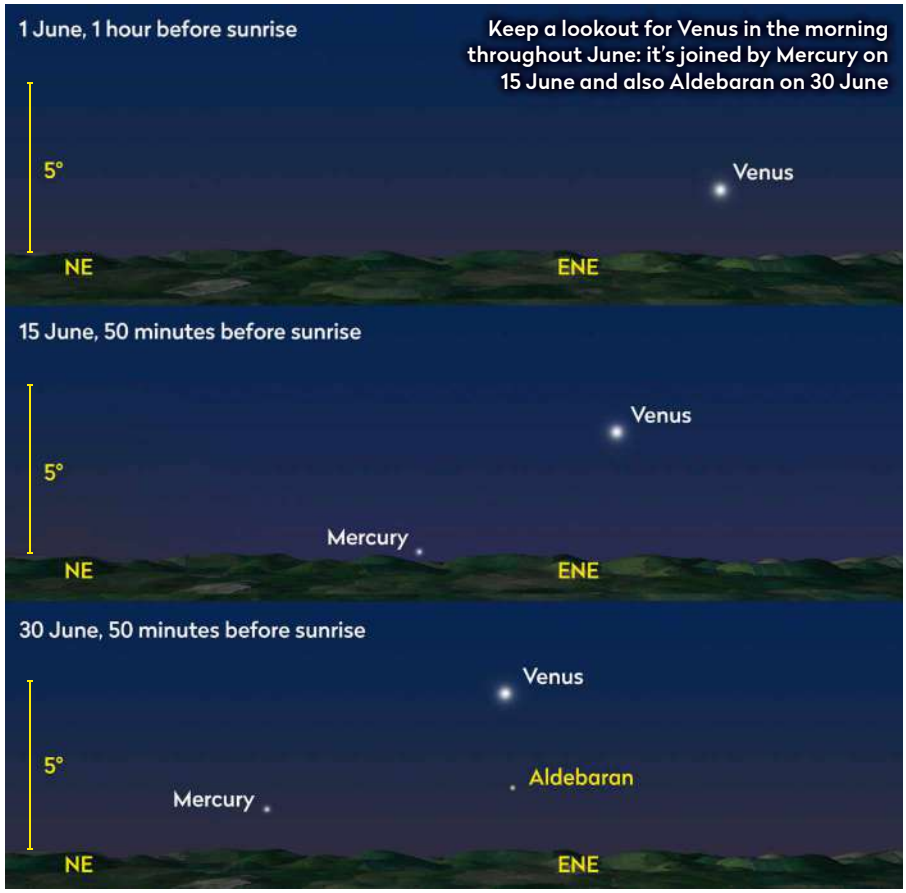

26 June, 07:20 BST (06:20 UT), closest separation
Moon
WARNING: Sun located 30° to the east
Venus
26 June, 11:05 BST (10:05 UT), both objects 60° up, due south
Moon
WARNING: Sun located 30° to the east
Venus
7x50 binoculars

▲ Venus as it appears through a pair of binoculars, separated from the Moon by 2.2°

PICK OF THE MONTH

Venus

Best time to see: 30 June, 30 minutes before sunrise
Altitude: 10°
Location: Taurus
Direction: East-northeast
Features: Phase, subtle markings on the planet's disc
Recommended equipment: 75mm, or larger



Whether you've been out all night looking for noctilucent clouds (NLCs), or perhaps have got up early to catch the June solstice sunrise on the morning of 21 June, don't forget to keep a lookout for the bright planet Venus. As you might guess from that last statement, Venus is currently a morning object. Located within Taurus, the Bull, the planet rises 80 minutes before the Sun at the start of June, increasing to 100 minutes by the month's end. It remains a fraction below mag. –4.0 during June and, despite a low morning altitude, this brightness should help you to see it given clear skies.

Through a telescope Venus appears gibbous and is decreasing in apparent size as it moves along a portion of its orbit on the far side of the Sun as seen from Earth. In the sky, the planet is slipping closer to the Sun's position in the sky.

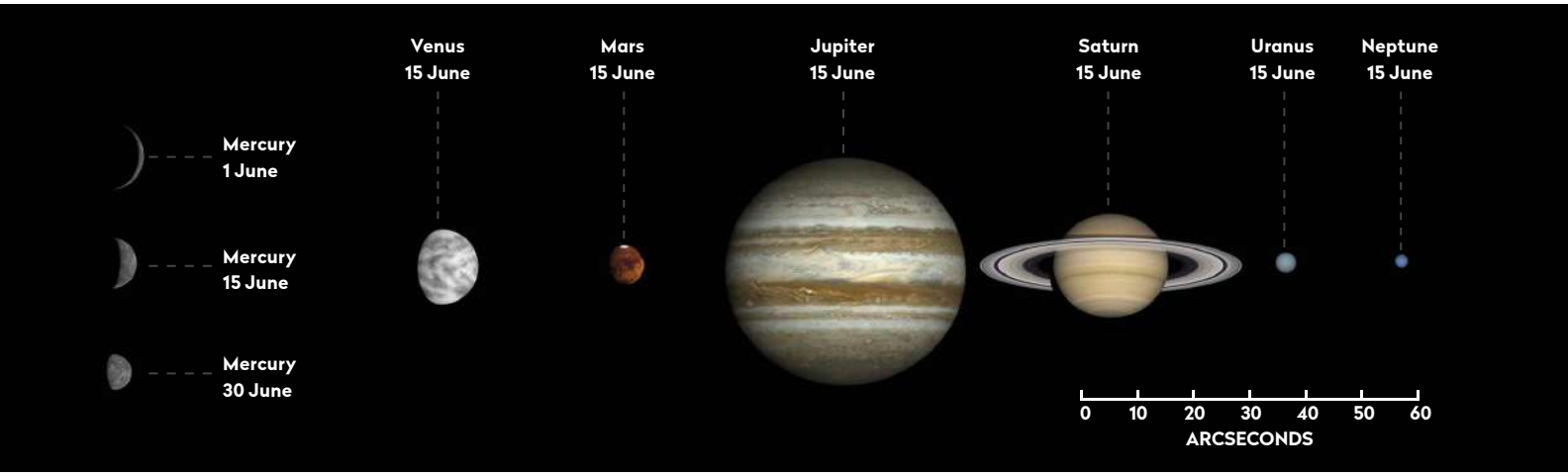
A slender 7%-lit waning crescent Moon sits close to the bright planet on the morning of 26 June and this should be an attractive sight, as long as you have a flat east-northeast horizon. The Moon will appear 2.2° above Venus as seen from the UK on this date and should be exhibiting the phenomenon known as earthshine, where the dark portion can be seen glowing gently against the lit crescent.

On 30 June, Aldebaran (Alpha (α) Tauri) is located below Venus, marking the right angle in a right-angle triangle with mag. –0.6 Mercury further to the left. Both Mercury and Aldebaran will be low and difficult to locate, but Venus will be a good guide if you want to try.

PETE LAWRENCE X 2

The planets in June

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 30 June, 30 minutes before sunrise
Altitude: 4° (very low)
Location: Taurus
Direction: Northeast

A morning planet, dim at the month's start and not well placed. It reaches greatest western elongation on 16 June when it shines at mag. +0.7 and rises 50 minutes before the Sun. On the 27th, a thin 3%-lit waning crescent Moon sits north of the mag. –0.3 planet. Mercury rises above the northeast horizon just over an hour before the Sun on this date, chasing mag. –3.8 Venus over the sky. The best view will be on the 30th, when Mercury shines at mag. –0.6 and rises 70 minutes before the Sun.

Mars

Best time to see: 30 June, 03:00 UT
Altitude: 22°
Location: Pisces
Direction: East-southeast

Mars is a morning planet, improving in appearance over June. On the 1st, it rises two hours before the Sun and shines at mag. +0.7. Through an eyepiece, it shows a gibbous phase, 6 arcseconds across on the 1st. At the month's start, it appears close to mag. –2.1 Jupiter, the planets appearing 1.7° apart on the 1st. The waning crescent Moon passes close to Mars on the mornings of the 22nd and 23rd. By the month's end, it will have brightened to mag. +0.5 with an apparent disc size of 7 arcseconds across.

Jupiter

Best time to see: 30 June, 03:00 UT
Altitude: 26°
Location: Cetus
Direction: Southeast

Jupiter is a mag. –2.1 morning planet this month. On 1 June it appears close to mag. +0.7 Mars, the pair separated by 1.7°. The last quarter Moon sits near Jupiter on the 21st and again as a waning crescent on the 22nd. Although Jupiter can be seen against dark twilight by the end of the month, it is unable to reach its highest position in the sky before sunrise. Following the solstice, conditions will improve.

On 25 June, Jupiter drifts east into Cetus. This is a part of the constellation that sits south of Pisces and east of the Circlet asterism.

Saturn

Best time to see: 30 June, 03:00 UT
Altitude: 22°
Location: Capricornus
Direction: South

Saturn is visible in the morning sky, shining at mag. +0.8 at June's start, but brightening to mag. +0.7 by its close. An 81%-lit waning gibbous Moon sits near to Saturn on the morning of the 18th. By the month's end, Saturn manages to reach an altitude of 22° as seen from the centre of the UK, before the brightening dawn twilight engulfs it.

Through a scope, the rings are now appearing to narrow. This month, the tilt angle reaches a low for 2022, varying between 12.1°–12.3°. This presents Saturn with a 'classic' appearance, with its polar regions extending north and south beyond the ring ellipse.

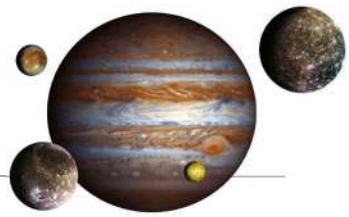
Uranus

The morning planet Uranus is not visible this month.

Neptune

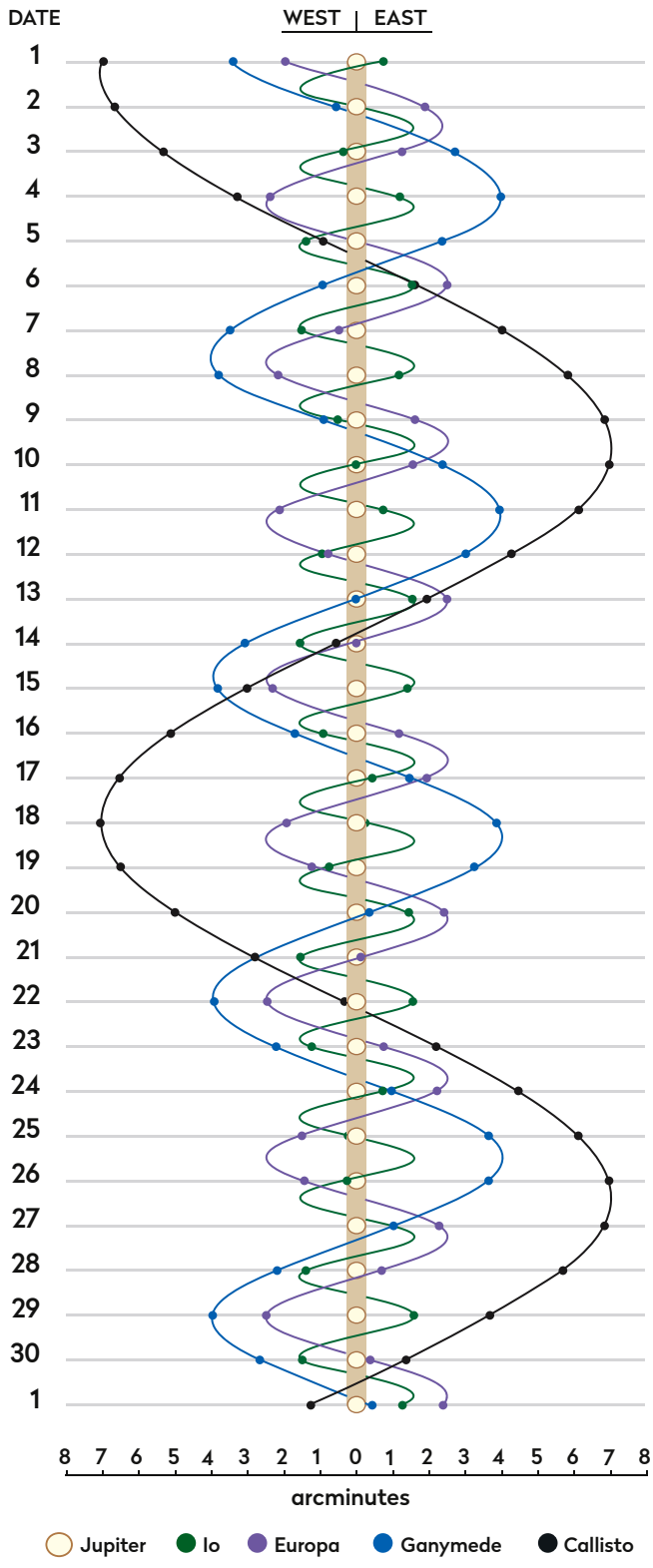
Neptune is a morning planet, but not viable for observation.

More ONLINE
Print out observing forms for recording planetary events



JUPITER'S MOONS: JUNE

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – JUNE

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Cirdet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

CHART: PETE LAWRENCE

When to use this chart

1 June at 01:00 BST
15 June at 00:00 BST
30 June at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in June*

Date	Sunrise	Sunset
1 Jun 2022	04:48 BST	21:28 BST
11 Jun 2022	04:42 BST	21:38 BST
21 Jun 2022	04:41 BST	21:43 BST
1 Jul 2022	04:46 BST	21:42 BST

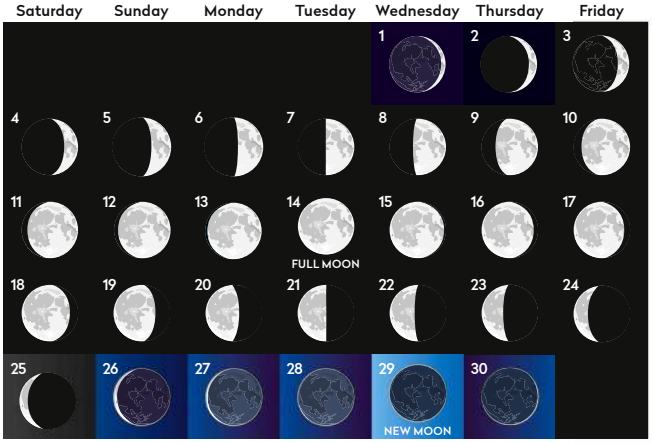
Moonrise in June*

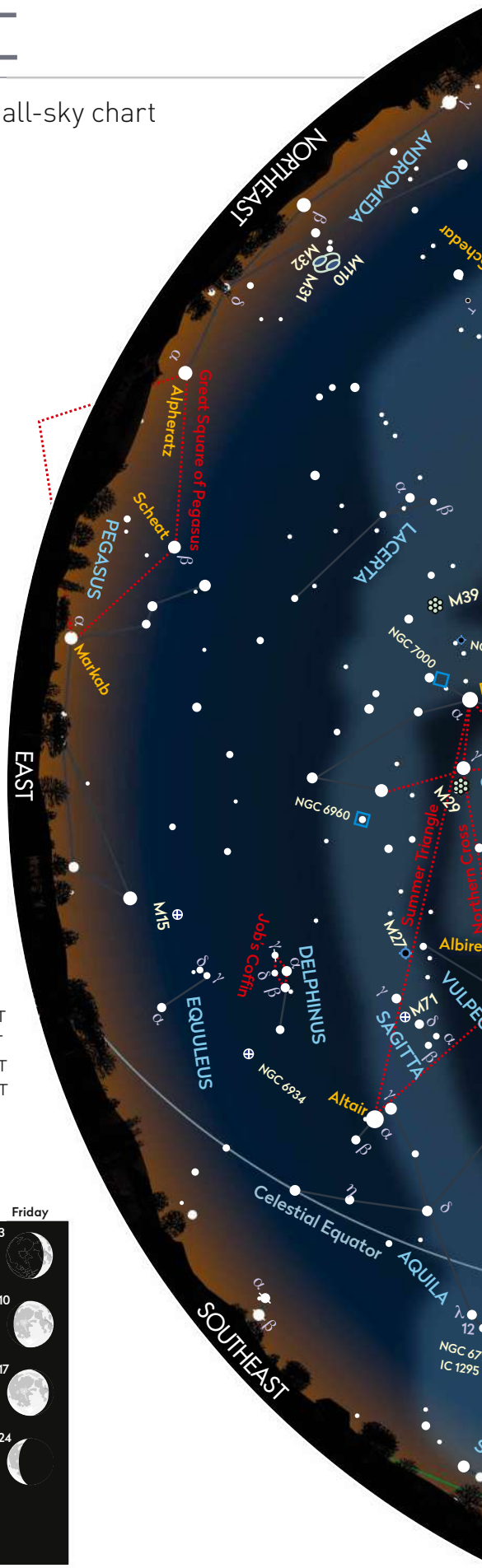
Moonrise times

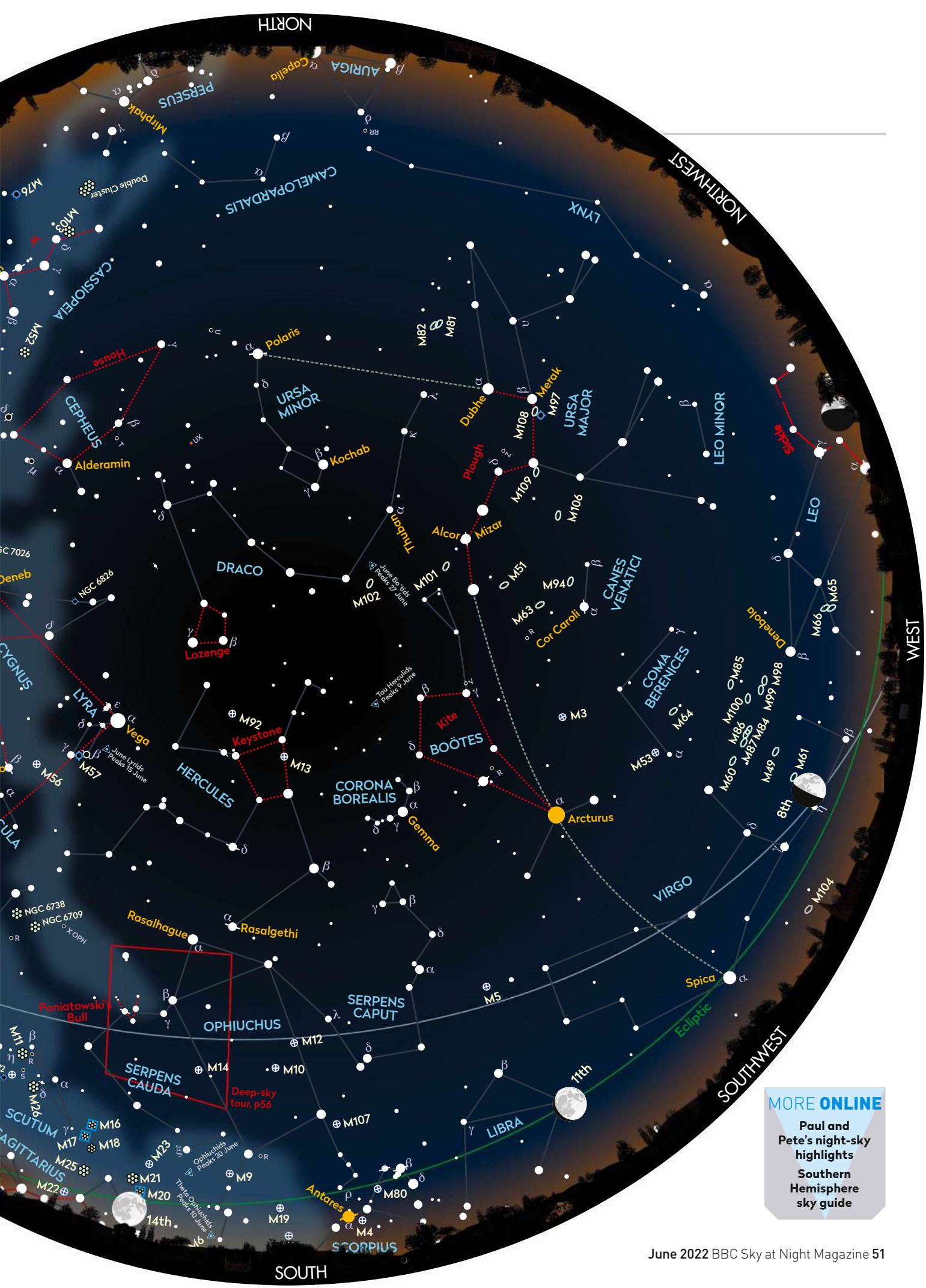
1 Jun 2022, 05:40 BST	17 Jun 2022, 00:52 BST
5 Jun 2022, 09:51 BST	21 Jun 2022, 01:39 BST
9 Jun 2022, 15:00 BST	25 Jun 2022, 02:26 BST
13 Jun 2022, 21:00 BST	29 Jun 2022, 04:24 BST

*Times correct for the centre of the UK

Lunar phases in June



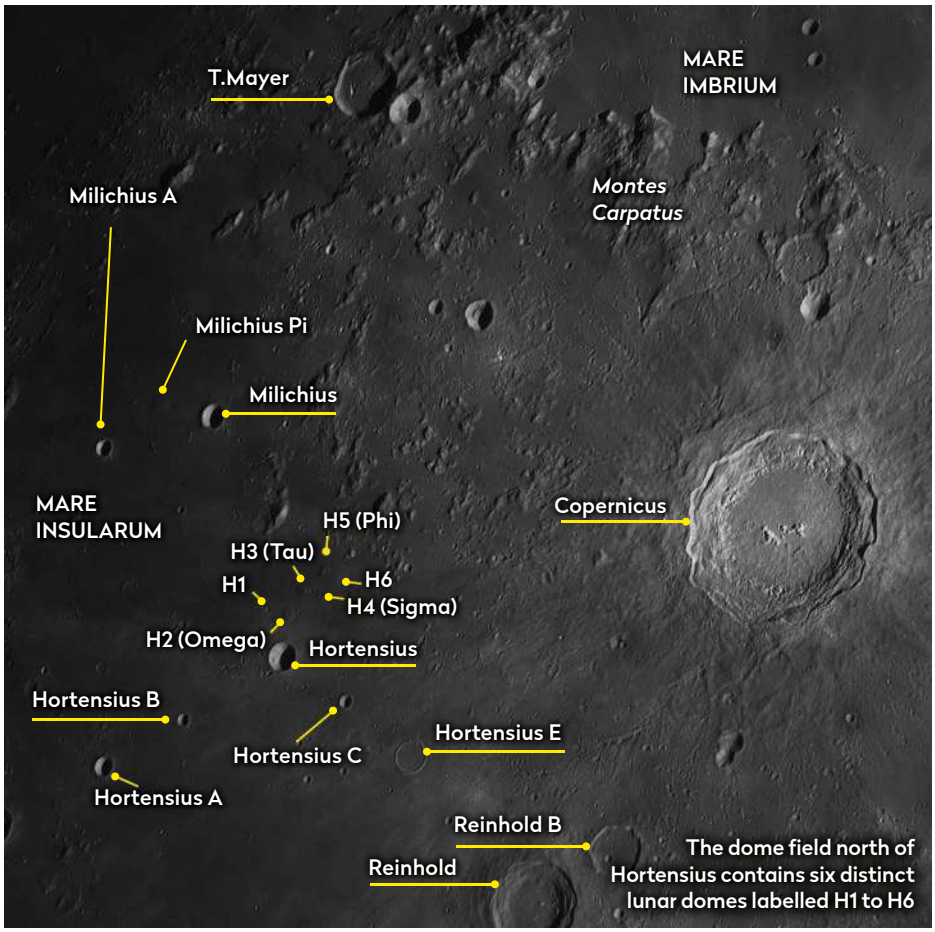




MORE **ONLINE**
Paul and Pete's night-sky highlights
Southern Hemisphere sky guide

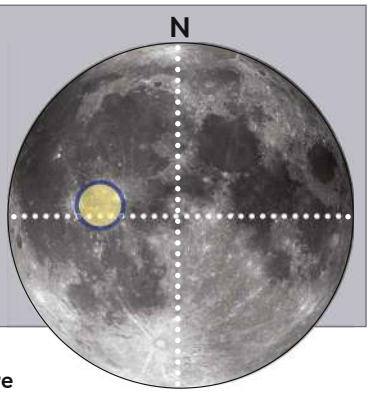
MOONWATCH

June's top lunar feature to observe



Hortensius

Type: Crater
Size: 15km
Longitude/Latitude: 28° W, 6.5° N
Age: Less than 1.1 billion years
Best time to see: Two days after first quarter (9 June) or one day after last quarter (22–24 June)
Minimum equipment: 100mm refractor



Hortensius is a small round crater in **Mare Insularum**, the Sea of Islands. It sits to the south of the mid-point between two dramatic ray craters; 31km Kepler (not shown) and 93km **Copernicus**. Another way to locate it, which will be more phase-friendly, is to first identify the circular form of 34km **T.Mayer**, a crater at the western end of the **Montes Carpatus** range which borders the southern shores of **Mare Imbrium**. **Hortensius** lies 280km to the south of T.Mayer, just south of the midpoint between T. Mayer and 40km Lansberg.

Hortensius itself is bowl-shaped with steep sides leading down to a small, 4km diameter, flat floor. Its nearest large neighbour is 48km **Reinhold**, 183km to the southeast, although it's the crater Copernicus which tends to dominate the scene.

Hortensius C, located 40km to the east-southeast, is a 6km mini-replica of Hortensius with the same shape and profile, right down to the circular floor. Continue the line from Hortensius through Hortensius C for the same distance again and you'll arrive at 15km **Hortensius E**, an impressive near-ghost of a crater. Completely filled with lava, all that remains of Hortensius E is an elevated outline of its outer rim. Continue the line from Hortensius through Hortensius E for the same distance again and you'll arrive at Reinhold, mentioned earlier.

The region just north of Hortensius appears relatively flat under direct light, but actually contains a very interesting set of lunar domes. Known as the **Hortensius Omega dome field**, after the largest example, **Hortensius Omega**, the region contains six domes, bulges on the lunar surface which are the remnants of volcanic activity. These are shield volcanoes, their characteristic shape formed when viscous lava pushed up through the lunar crust.

The domes rise to a height of 400m and range in diameter from 6–8km. Their relatively low height means they are best seen when the Sun is low in their sky, in other words when the lunar terminator is nearby. Each dome has a 1km pit in its summit, except for one that has two and one that appears to have none. The main form of the domes can be seen with a 100mm instrument, but the pits are tiny and will require either a large scope or a high-resolution imaging setup to resolve properly.

To the north of the domes is a rugged area of hills and massifs to the west of Copernicus. West of the largest massifs here is the 13km crater **Milichius**, itself associated with a single dome called **Milichius Pi**. This has a diameter of 10km and like four of the Hortensius domes contains a single pit, here 1.6km in diameter.

Hortensius is bowl-shaped with steep sides leading down to a small, at oor

The line running southwest of Hortensius is similar in nature to that running from Hortensius to Reinhold. First along the southwest line, 59km from Hortensius is 7km **Hortensius B**.

Continue for a further 50km and you'll arrive at 10km **Hortensius A**. Like Hortensius C mentioned earlier, A and B are very similar in appearance to Hortensius, being bowl-shaped with a small, flat central floor.

PETE LAWRENCE X 3

COMETS AND ASTEROIDS

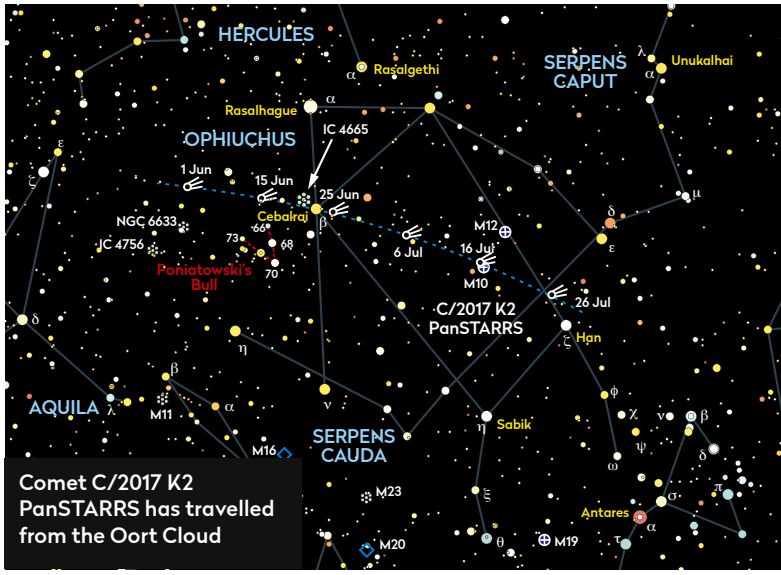
Comet C/2017 K2 PanSTARRS will brighten favourably throughout June

Comet C/2017 K2 PanSTARRS is predicted to continue brightening through June and remains well placed for UK observation. If it follows predictions, it will begin the month with an integrated magnitude of +8.8, making it binocular-friendly. By the month's end, it should have brightened to mag. +8.1. The June solstice occurs on 21 June, representing the period when the night skies are brightest for the year. For those in the UK's far north the eternal twilight is obvious, while those in the south fare better in the middle of the night. This means that although the comet will be brightening over June, so will the sky, only starting to darken subtly by the time the end of the month arrives.

The good news here is that the comet's brightening will continue beyond June, with it reaching a peak brightness of mag. +7.1 in January 2023. Unfortunately, the UK will lose sight of K2 PanSTARRS well before then as it tracks ever further south to become a target only visible from the Southern Hemisphere.

This month K2 PanSTARRS is well positioned, starting its June track 3° to the east of the mag. +3.7 binary star system 72 Ophiuchi. It then appears to move southwest, clipping the southern edge of IC 4665 on the night of 20/21 June. It appears close to mag. +2.8 Cebalrai (Beta (β) Ophiuchi) on the nights of 21/22 and 22/23 June, when it is around 8 arcminutes west of the star at 01:00 BST (00:00 UT) on the 23rd. PanSTARRS's brightness is estimated to be mag. +8.2, but this is also the time when the sky will appear brightest due to the June solstice.

C/2017 K2 PanSTARRS is an Oort Cloud comet with a hyperbolic orbit. Its closest approach to the Sun is on 19 December 2022.

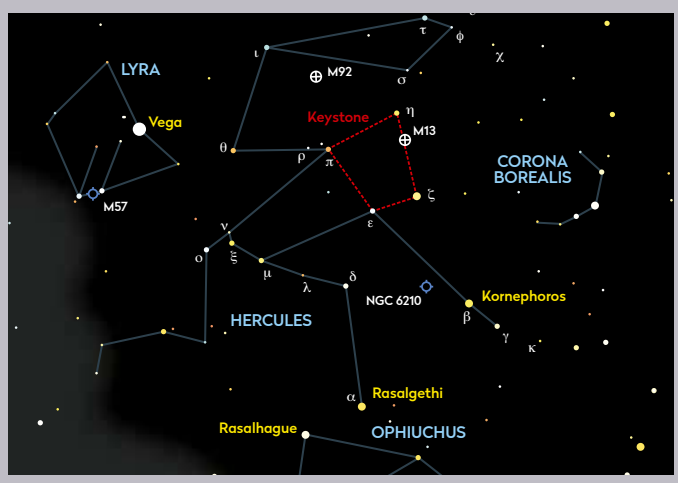


Comet C/2017 K2 PanSTARRS has travelled from the Oort Cloud

STAR OF THE MONTH

Kornephoros, the 'club bearer' in Hercules

▼ The luminous yellow giant star Kornephoros is located 139 million lightyears away



Hercules, the Hero is a faint and sprawling constellation. It lacks any bright stars, but is saved by a faint asterism known as the Keystone. It's remarkable how identifiable this shape is, considering its brightest star is mag. +2.8 Zeta (ζ) Herculis. Heading south and a bit west from Zeta Herculis brings you to Kornephoros (Beta (β) Herculis), which shares its mag. +2.8 brightness with Rasalgethi (Alpha (α) Herculis), 13° to Kornephoros's east-southeast.

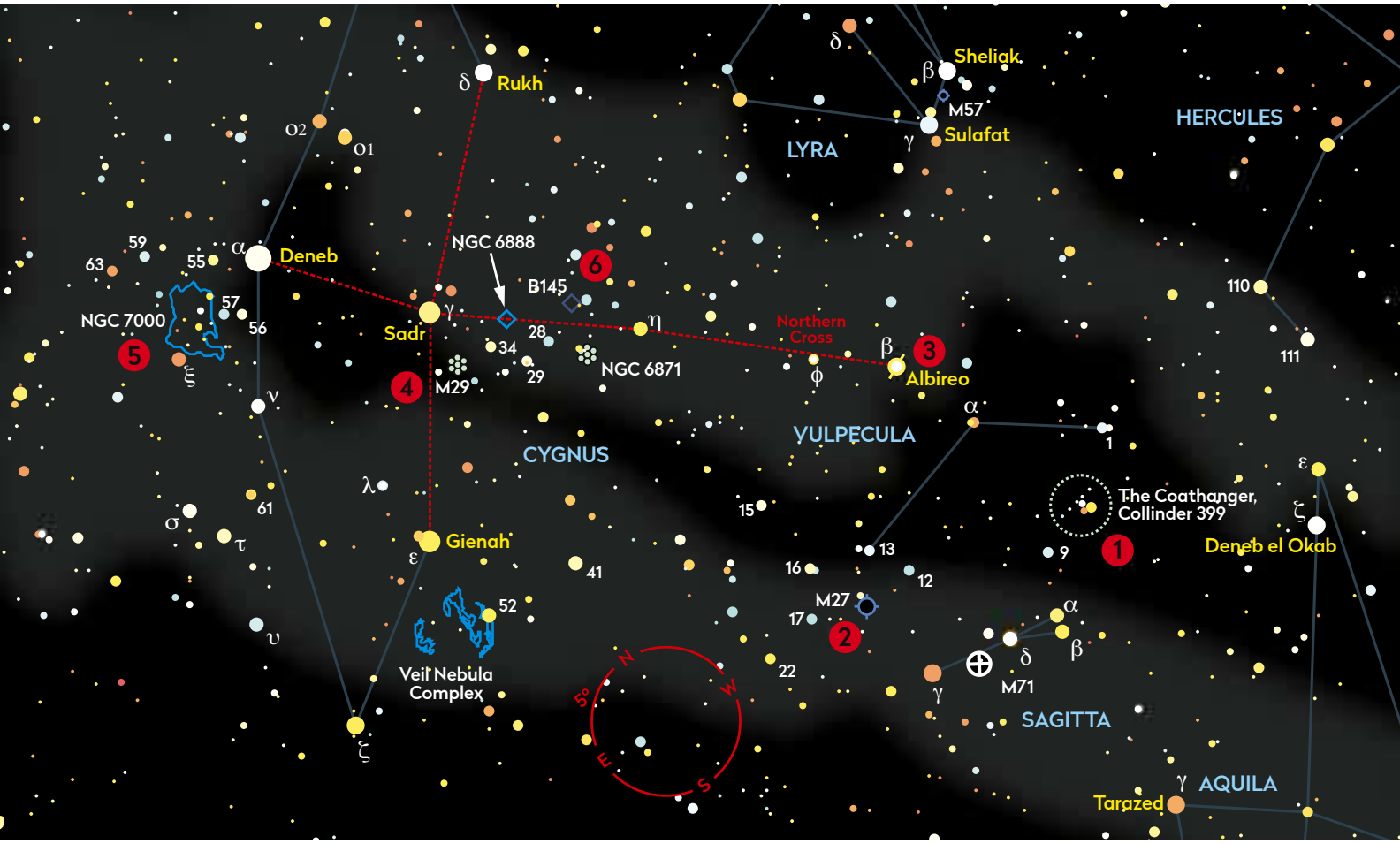
Kornephoros means 'club bearer', and it was previously named Rutilicus, a corruption of the Greek word for 'armpit'. It's a spectroscopic binary system with a period of 410 days. The primary is 2.9 times more massive than our own Sun and has a diameter 17 times larger. Its spectral type is G7 IIIa, a yellow giant star in the throes of expanding as it moves off the main-sequence of stellar evolution. The III indicates that Kornephoros is a giant star with the letter 'a' indicating it's a bit brighter than a typical giant.

Not much is known about the secondary except that it's 0.9 times as massive as the Sun. The system is located 139 lightyears away and it was resolved by an Earth-based observatory using the 'speckle interferometry' technique. This involved the use of the Hale Telescope, while follow-up observations using the Hipparcos satellite in 2005 allowed more detail to be determined in respect of the orbit. This is known to be elliptical with an eccentricity of 0.55. Eccentricity is a measure of the ellipticity of an orbit, 0 being circular and 1 being parabolic and open. The orbit is also inclined by 53.8° to our line of sight.

BINOCULAR TOUR

With Steve Tonkin

This month's wide- eld targets include the Dumbbell and North America Nebulae



1. The Coathanger

10x 50 Let's begin with a summer star party piece. Put mag. +4.4 Alpha (α) Vulpeculae at the north of the field of view, and the Coathanger (or Collinder 399), will be near the southern edge. It lies in a darker part of the Milky Way, so even small binoculars will reveal the 10 brightest stars that give this asterism its name. It was first recorded by Persian astronomer Abd al-Rahman al-Sufi in his AD 964 *Book of Fixed Stars*. ☐ **SEEN IT**

2. The Dumbbell Nebula

10x 50 Next is the easiest planetary nebula for binoculars. Identify Gamma (γ) Sagittae and pan over 3° in the direction of 15 Vulpeculae where, even in suburban skies, you will find a small glowing cloud. This distant object, the Dumbbell Nebula, is 1,360 lightyears away. Initially it will appear rectangular but, with patience, you should discern the narrowing in the middle that gives it its common name. ☐ **SEEN IT**

3. Albireo

10x 50 Albireo (Beta (β) Cygni) marks the Swan's eye. This double star has a separation of 34 arcseconds, a good test for 10x magnification: if you don't see two stars, make sure that your focus is perfect and try mounting the binoculars. Once you have split it, notice the beautiful contrast between the golden mag. +3.1 primary and azure mag. +5.0 secondary. Albireo was recently revealed as an optical double, a line-of-sight coincidence. ☐ **SEEN IT**

4. M29

15x 70 Put mag. +2.2 Sadr (Gamma (γ) Cygni) at the north of a 15x70's field of view and the mag. +6.6 cluster, M29, will be near the centre. This is a fairly unremarkable target in smaller binoculars but, on a good night, 15x70s will resolve around a dozen of the 50 or so of these hot blue giants, each with a luminosity of over 150,000 Suns. The brighter stars form a 'cooling tower' shape. ☐ **SEEN IT**

5. The North America Nebula

10x 50 The North America Nebula, NGC 7000, is a large bright patch of nebulosity whose centre is 3.5° east-southeast of Deneb (Alpha (α) Cygni). If it's not immediately visible, try instead to detect the dark nebula that forms the 'Gulf of Mexico'. This emission nebula is about 100 lightyears across and appears to us as four times the Moon's size. ☐ **SEEN IT**

6. Barnard 145

15x 70 Our final object is another of these intervening clouds of dust. 'The Man Who Never Slept', EE Barnard, described them as "holes" and "lanes" cutting through the Milky Way, before he realised their true nature. Identify mag. +3.9 Eta (η) Cygni, and use the chart (above) to find 25 Cygni, at mag. + 5.1. Barnard 145 is the inky-black 'inlet' into the Milky Way, 0.75° to the northeast. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

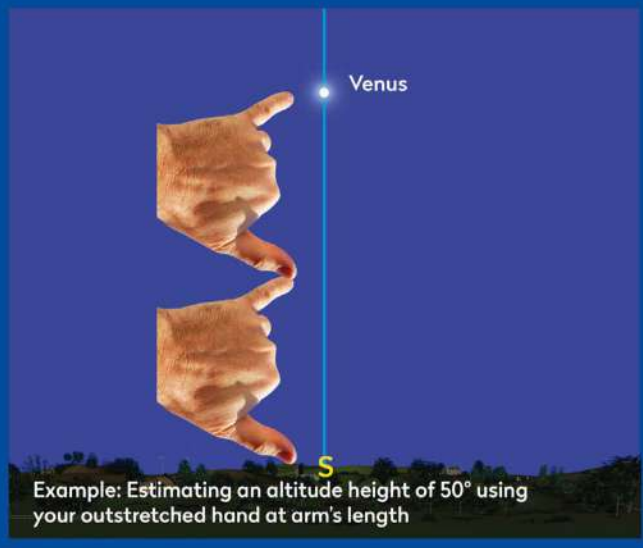
CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

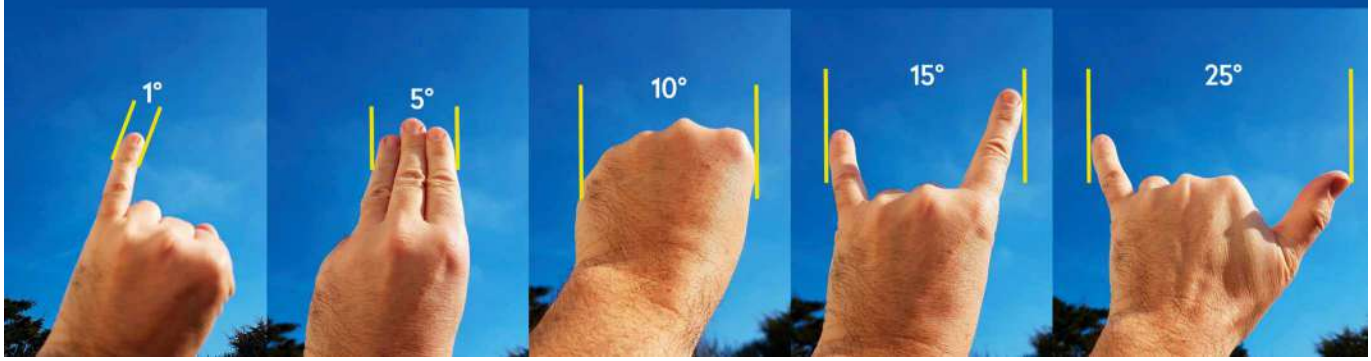
We reveal several methods to help with spotting Venus during the day

Highest altitude of Venus when the planet is due south

Date	Time	Altitude*
1 June	10:44 BST (09:44 UT)	48°
6 June	10:47 BST (09:47 UT)	50°
11 June	10:50 BST (09:50 UT)	52°
16 June	10:54 BST (09:54 UT)	54°
21 June	10:58 BST (09:58 UT)	55°
26 June	11:03 BST (10:03 UT)	56°
1 July	11:08 BST (10:08 UT)	58°

* Altitude correct for the centre of the UK and will vary slightly with location





▲ **Work out how far Venus is from the Sun in degrees by using your hand at arm's length, but take care not to look at the Sun directly**

June's challenge is to locate the planet Venus. You may think this is easy, after all Venus is the brightest of the planets and at present is located approximately 30° to the west of the Sun in the morning sky. Not much of a challenge then... However, we want you to locate it in the day, which is not quite as straightforward.

Before we continue, it's important to mention that although the Sun is 30° to the east of the planet, it's still a potential danger. A good way to protect yourself from its harmful rays is to stand in the shadow of a fence or building so you can't see the Sun, but just the area of sky to the right of it.

So how do you go about looking for a bright planet during the day? Using nothing more than your eyes, there are a couple of ways to approach this. One is to work out how far Venus is from the Sun in degrees and use your hand at arm's length as a general guide to its whereabouts. Your clenched fist at arm's length is approximately 10° across, your outstretched hand 25°. These measures can be used with care to gauge an angular distance from the Sun or height above the horizon, enough to put you in the right area. Measures like this are a valuable skill to learn for many aspects of astronomical planning.

Locate Venus against a dark sky and stay with it past sunrise

The table above shows the altitude of Venus above the southern horizon, this being another convenient way to locate it as long as the weather is clear at the times shown. Then there's the 'hanging on' method. For this you can get up before sunrise, locate Venus against a dark sky and stay with it past the point of sunrise.

Finally, there's the Moon locator method. This only works if the Moon is nearby of course, a situation that occurs on one or maybe two days every month. The Moon will appear close to Venus on 26 June and, as long as you can locate the Moon during the day, Venus should be relatively easy to spot to the south and west of it on this day.

Clear skies are a must for this of course, but non-hazy conditions with well-defined clouds can work well too because such features can help you to navigate around patches of the sky. They can also work against you by hiding Venus just at the moment you're looking in the right direction. Whichever method you use, if you succeed, you'll certainly feel a sense of achievement. Once you've done this for the first time, it also makes subsequent efforts much easier.

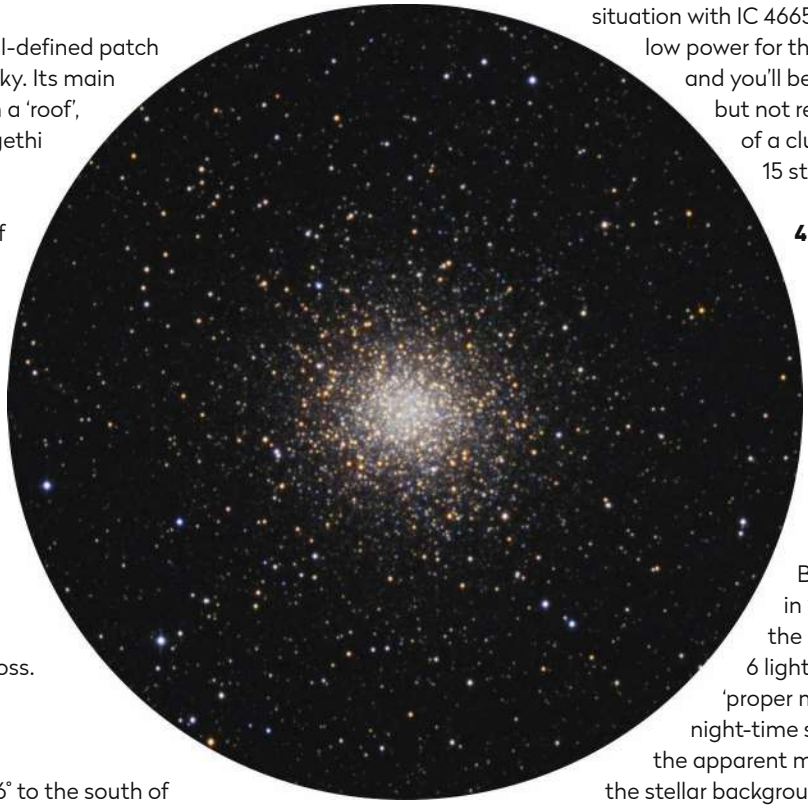
DEEP SKY TOUR

This month we take in sights in the constellation of Ophiuchus, the Serpent Bearer

1 IC 4665

Ophiuchus is a large ill-defined patch of the early summer sky. Its main form appears as a box with a 'roof', the apex marked by Rasalgethi (Alpha (α) Ophiuchui) representing Ophiuchus's head. The eastern vertex of the roof connects with the box at (Cebalrai (Beta (β) Ophiuchi) and you'll find our first tour target, the large open cluster IC 4665, 1.3° to the north of this star.

IC 4665 is a young and close cluster, estimated to be 40 million years old and only 1,400 lightyears away. Best viewed with a low-power eyepiece, it appears 45 arcminutes across. ☐ **SEEN IT**



▲ **The globular cluster M14 was discovered in 1764 by Charles Messier**

Opposite page: the inset of Target 4 represents an inverted view through an eyepiece

2 NGC 6426

Our next target lies 1.6° to the south of mag. +2.8 Cebalrai. Here you'll find the mag. +11.1 globular cluster NGC 6426. It's more difficult to see as it's fairly dim and quite small with a diameter of 3 arcminutes. A 250mm scope shows it as little more than a faint smudge, barely 2.5 arcminutes across. With averted vision and high magnification it should be possible to see that the smudge is brightening towards the centre. Increasing the aperture to 300mm will show little more than this to be honest, the faint, centre-bright patch being easier to see, but not showing any stellar granularity. This globular is located at a distance of 67,200 lightyears. ☐ **SEEN IT**

3 Collinder 350

Our next target is open cluster Collinder 350. To locate it, head 2° south of Cebalrai to mag. +6.2 HIP 86831. Head 0.8° east for mag. +3.9 Gamma (γ) Ophiuchi and 0.8° south-southeast to mag. +6.4 HIP 87224. This orange star is the north vertice of a right-angled triangle with mag. +7.5 HIP 87244 and mag. +6.6 HIP 86969, both also orange. Collinder 350 sits between HIP 87224 and HIP 86969.

At mag. +6.1, this is a tricky object because it's large, sparse and sits on the Milky Way's edge. As was the situation with IC 4665, Collinder 350 requires a low power for the best view. Go too high and you'll be looking at stars within it, but not realising that they are part of a cluster! In total, there are 15 stars to be see. ☐ **SEEN IT**

4 Barnard's Star

Our next stop is unusual in that's its just a star. Located 3.5° east of Cebalrai and 0.7° west-northwest of mag. +4.8 66 Ophiuchi, is mag. +9.5 HIP 87937. This is Barnard's Star, named after its discoverer EE Barnard, who identified it in 1916. It's a neighbour of the Sun at a distance of 6 lightyears. It shows the largest 'proper motion' of any of the night-time stars. This term describes the apparent movement of a star against the stellar background. In the case of Barnard's Star it's 10.4 arcseconds per year. ☐ **SEEN IT**

5 M14

Head 7.5° south of Cebalrai and nudge 2° west to find our next target, globular cluster M14. Shining with an integrated magnitude of +7.6, this Messier-listed globular appears large through the eyepiece of a 150mm scope. Using a high power with a 150mm scope just starts to reveal some granularity in the globular's texture. Larger apertures will show that the globular is slightly elongated in a northeast-southwest orientation. Above 250mm a few resolved stars may be seen, but even a 300mm struggles to show much more than just a few stars spread over an area 9 arcminutes across. ☐ **SEEN IT**

6 NGC 6366

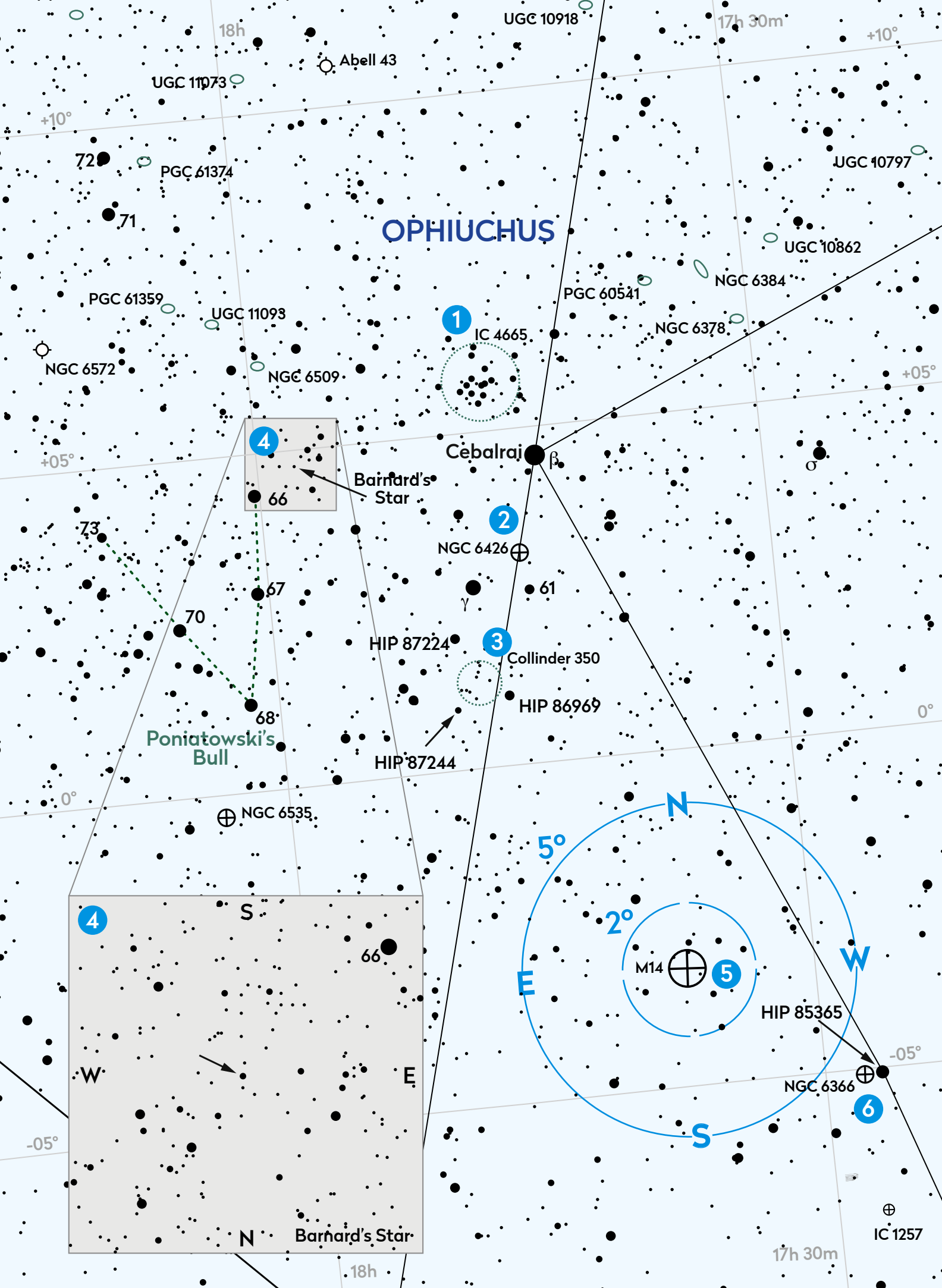
Globular cluster NGC 6366 is easy to locate as it sits 16 arcminutes to the east of mag. +4.5 HIP 85365. This globular responds favourably to aperture, although at the lower end you probably won't see a great deal more than a featureless glow with no central condensation nor any resolved stars. A pair of tenth magnitude stars sit on the HIP 85365 side of the globular and there's a closer pair of 12th magnitude stars on its southern side. By using an aperture of 250mm, it's possible to see a few resolved stars scattered over a 4-arcminute area. A 300mm aperture increases the number of faint stars as well as extending the area over which they are seen to around 8 arcminutes. ☐ **SEEN IT**

MICHAEL BREITE/ STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

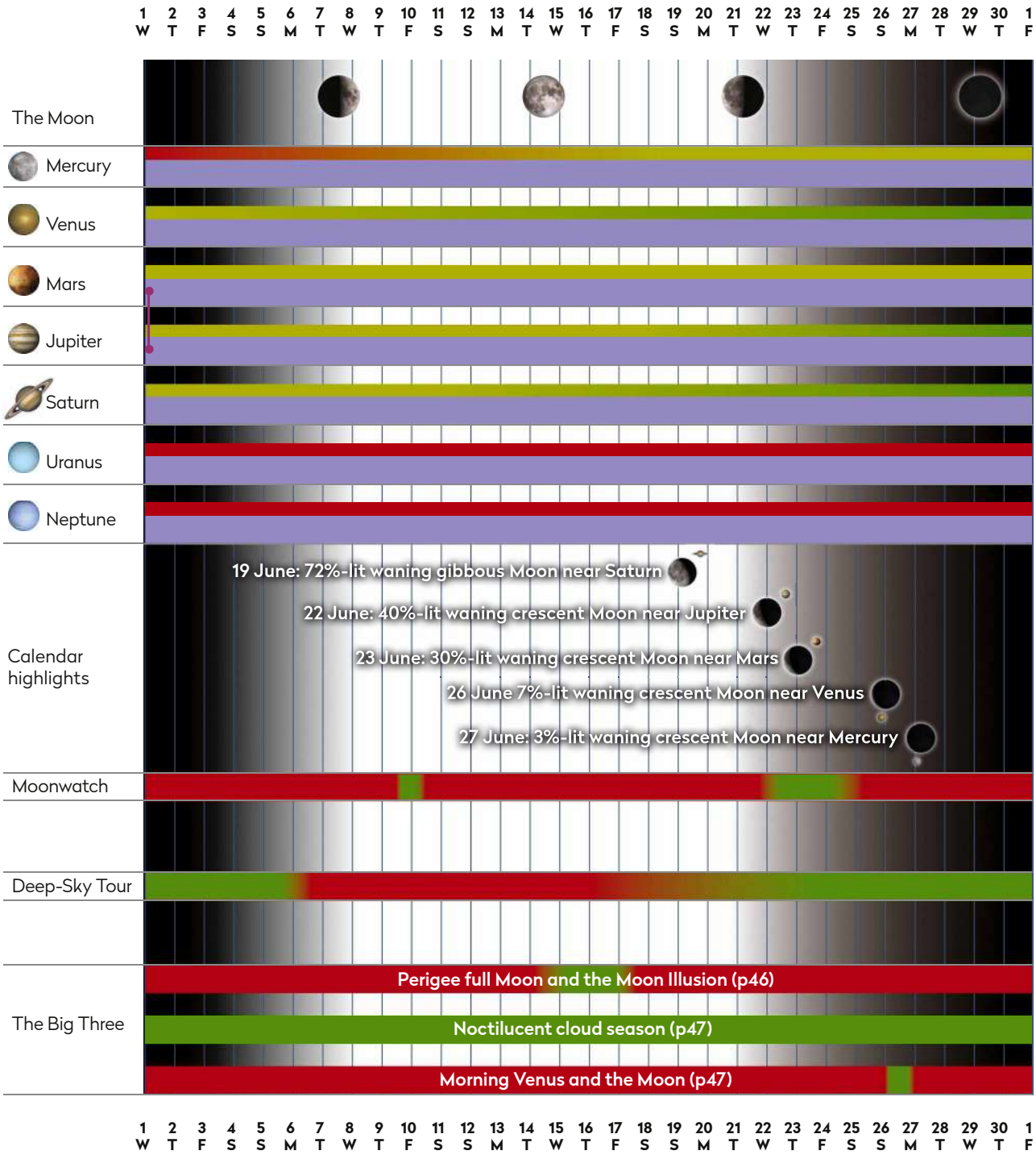
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.


OPHIUCHUS
UGC 10918
17h 30m
+10°
18h
Abell 43
UGC 11073
+10°
72
PGC 61374
71
UGC 10797
UGC 10862
NGC 6384
PGC 60541
PGC 61359
UGC 11093
1
IC 4665
NGC 6378
NGC 6572
NGC 6509
+05°
4
Cebalrai
β
σ
+05°
Barnard's Star
66
2
73
NGC 6426
67
61
γ
70
HIP 87224
3
Collinder 350
HIP 86969
68
Poniatowski's Bull
HIP 87244
0°
NGC 6535
0°
N
5°
2°
E
W
M14
5
HIP 85365
-05°
NGC 6366
6
S
4
S
66
W
E
N
Barnard's Star
-05°
IC 1257
17h 30m
18h

AT A GLANCE

How the Sky Guide events will appear in June


1 W 2 T 3 F 4 S 5 S 6 M 7 T 8 W 9 T 10 F 11 S 12 S 13 M 14 T 15 W 16 T 17 F 18 S 19 S 20 M 21 T 22 W 23 T 24 F 25 S 26 S 27 M 28 T 29 W 30 T 1 F
The Moon
Mercury
Venus
Mars
Jupiter
Saturn
Uranus
Neptune
Calendar highlights
19 June: 72%-lit waning gibbous Moon near Saturn
22 June: 40%-lit waning crescent Moon near Jupiter
23 June: 30%-lit waning crescent Moon near Mars
26 June 7%-lit waning crescent Moon near Venus
27 June: 3%-lit waning crescent Moon near Mercury
Moonwatch
Deep-Sky Tour
The Big Three
Perigee full Moon and the Moon Illusion (p46)
Noctilucent cloud season (p47)
Morning Venus and the Moon (p47)
1 W 2 T 3 F 4 S 5 S 6 M 7 T 8 W 9 T 10 F 11 S 12 S 13 M 14 T 15 W 16 T 17 F 18 S 19 S 20 M 21 T 22 W 23 T 24 F 25 S 26 S 27 M 28 T 29 W 30 T 1 F

KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

It's love at first light!

ATIK CAMERAS

The Heart Nebula imaged by Julian Shroff with an Apx60

Introducing the Apx26, Atik Cameras' brand-new 26-megapixel CMOS camera, and latest addition to the Apx series.

Hot on the heels of the Apx60 is the Apx26, utilising the Sony IMX571 CMOS sensor. This 26-megapixel sensor has low read noise, high quantum efficiency, and 16-bit analogue-to-digital conversion. It's the perfect combination of versatility and large-format imaging.

The Apx26 comes complete with high-performance cooling, anti-condensation and anti-reflection optics, as well as easy chip adjustment. The camera has a large memory buffer to prevent image artefacts and dropped frames. Additionally, the Apx26 is compatible with Atik's intuitive software, and offers customary premium build quality.

You can order the Apx26 NOW!
See our website for details of our worldwide dealers

See the full Atik range
atik-cameras.com

Apx26

WIN!

To celebrate the launch of our 26-megapixel camera, we're offering you the chance to win a brand-new Apx26. Simply scan the QR code or head over to the Apx26 competitions page on our website, and use the code **S@N22** to enter. Competition closes 29 July 2022. T&C's apply.

Freeware EXPLORED

There's a wealth of free astronomical software available online to enhance your observations. Pete Lawrence looks at some of the best on offer

Computers and astronomy have always been well matched partners. While the huge amount of data available in astronomy today and repetitive calculations would be taxing for humans to manipulate manually, they present no such difficulty for modern computers.

That's why there is a great selection of astronomy software, covering everything from trivial tasks like calculating the positions of Jupiter's four main moons, up to taxing simulations of the whole Universe. Amateur astronomers have a rich library of applications to choose from – some are commercial, costing anything from a few to several hundred pounds, but many options are free.

In this article we will look at a few of these 'freeware' applications, many of which have been around for a while. The test of time has seen these pieces of software refined to a point where, once used, they can become an integral part of the observing experience. Although our list is not exhaustive, we hope it will help you discover some of the incredible free astronomical programs out there.

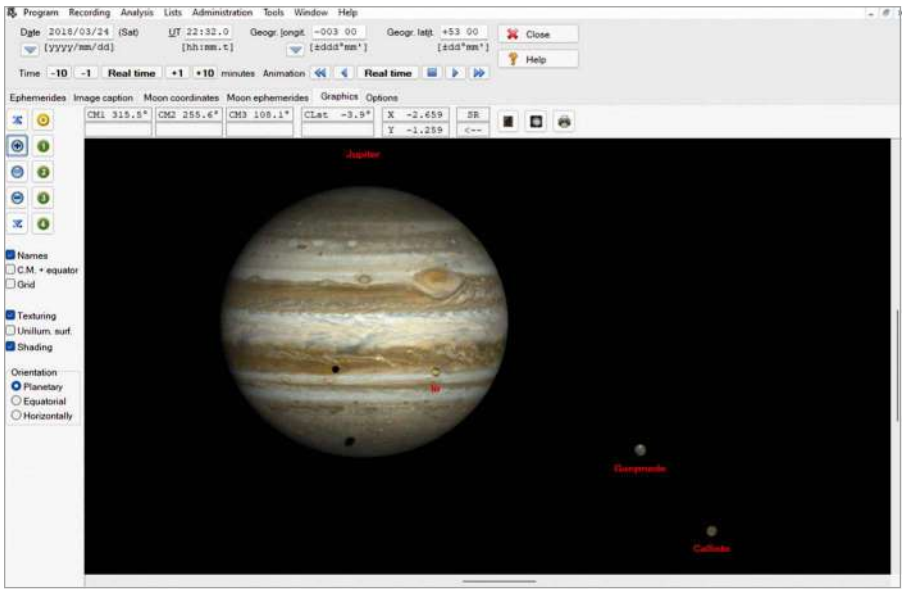
Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

The sky simulation program Stellarium has many useful plug-ins

GETTY

Solar System freeware

These apps deal with objects within the Sun's family, and include simulation, planning and reference programs



▲ **WinJupos can show the positions of moons, like Jupiter's, and track important events**

WinJupos

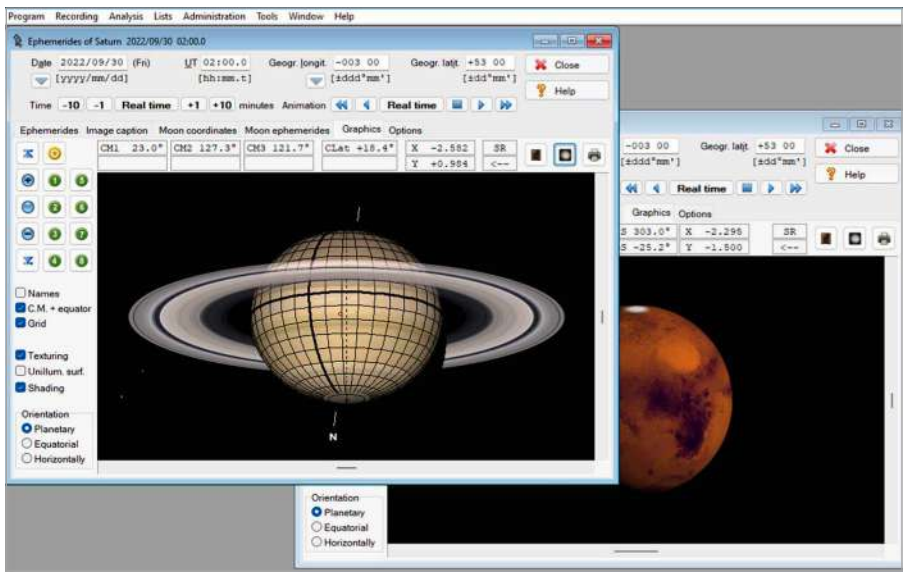
http://jupos.org
Download: **http://jupos.org/gh/download.htm**
Operating System (OS): **Windows 2000 – 11; Linux/Mac OS (with Wine)**

WinJupos has gone through many versions over time, each adding to the amazing collection of functions this program has to offer. As its name suggests, it's a native Windows application, but although the 'Jupos' part suggests it is Jupiter specific, it actually covers all of the main planets in the Solar System, as well as the Moon and the Sun. Its official description defines it as a free application for processing and analysing planetary images, but it's much more than this and is actually the software equivalent of a Swiss Army Knife for the Solar System.

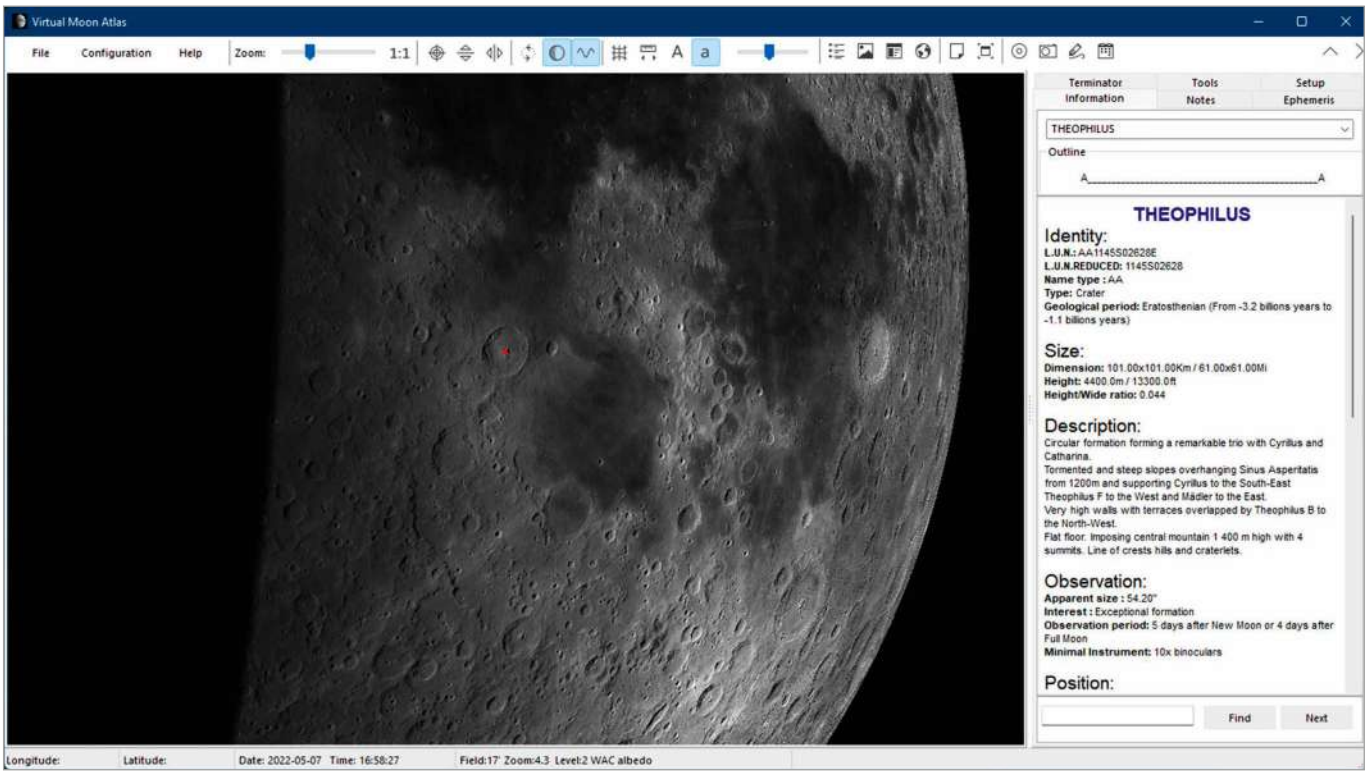
WinJupos generates detailed ephemerides – data tables – for the bodies it covers. It can show simulated views for each target and, where applicable, show positions of the target's main moons. In the case of Jupiter and Saturn, this includes showing moon events such as transits, eclipses and shadow transits. It's extremely useful for calculating globe coordinates, which can then be used to augment observations or measure the location of features on a planet.

The program includes powerful image analysis features. These can be used to track the movement of features in a gas planet's atmosphere, for example. It's also possible to generate a variety of maps from analysed images, combine results to cover extended areas and present them using a variety of different projections.

WinJupos also offers advanced image adjustment functions, such as de-rotation. This allows you to image a fast-rotating planet over a timespan that would normally blur the photo because of the planet's rotation, and eliminate that blur by cleverly winding the appearance of a planet back to a common time. ▸



▲ **The app generates detailed ephemerides and simulated views of major planets**



Virtual Moon Atlas

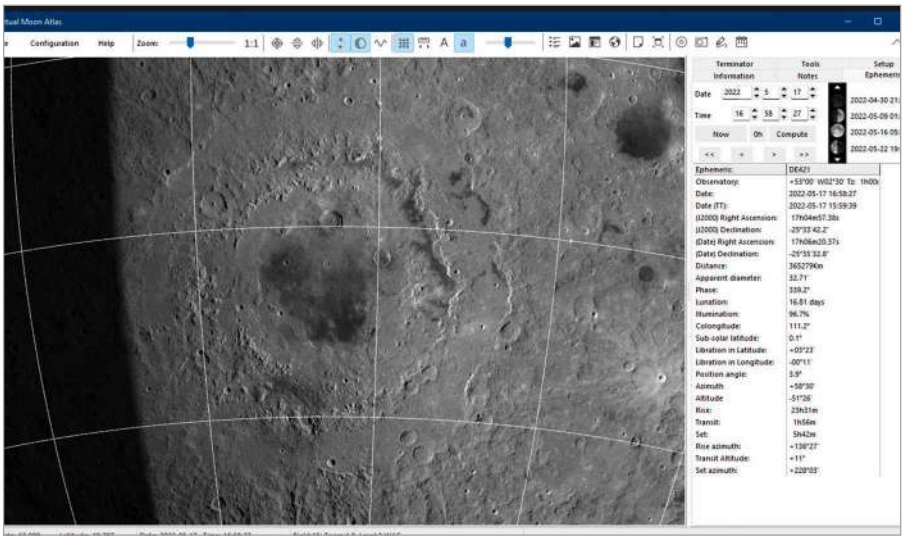
▲ **The Virtual Moon Atlas allows you to familiarise yourself with a chosen target thanks to detailed information panels**

https://ap-i.net/avl/en/start
Download: **https://ap-i.net/avl/en/download**
OS: **Windows 7/8/10; Linux/macOS (with Wine)**

The Virtual Moon Atlas is a digital globe for exploring the Moon. Using a series of ever more detailed images, it creates a seamlessly interactive view of the Moon. An ephemeris generator allows you to show the Moon's state for any date and time, providing detailed values for the Moon's position, phase, co-longitude, rise and set times, and more. Lunar libration (its rocking motion) is applied to the generated globe and this, along with the phase, can be toggled on and off.

Specific features can be searched out, located and marked, and you can read up on detailed information in a side panel. It's great for lunar exploration, and you can plan future observing sessions with it, optimising the view for a chosen feature. The software can also suggest interesting features to look out for on a given date and time. The default globe shows the side of the Moon which faces Earth, but it's possible to go beyond this view and spin the lunar globe round fully to see what's on the far side too.

There are many other tools that allow you to explore different aspects of the Moon. For example, overlays can be applied which reveal physical aspects such as surface height, geology, crust thickness; and the location of specific elements and minerals.



▲ **The VMA allows you to investigate features located anywhere on the Moon's globe**

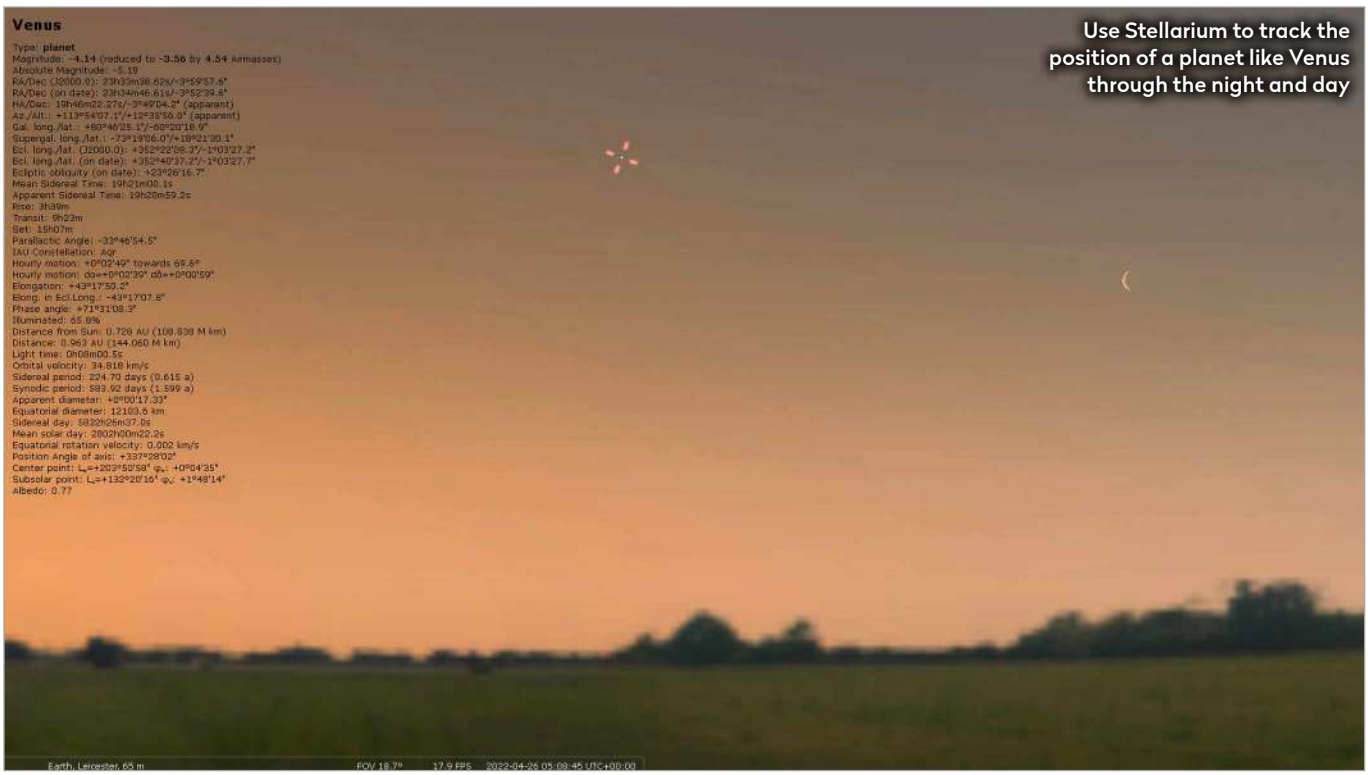
Also consider

Occult For lunar occultation prediction and analysis **www.lunar-occultations.com/iota/occult4.htm**

Helio v4.1 A solar orientation visualiser and observational data generator **www.petermeadows.com/html/software.html**

Sky simulation freeware

Sky simulation software is designed to show the night sky as it will appear from any location on any date and at any time past, present or future



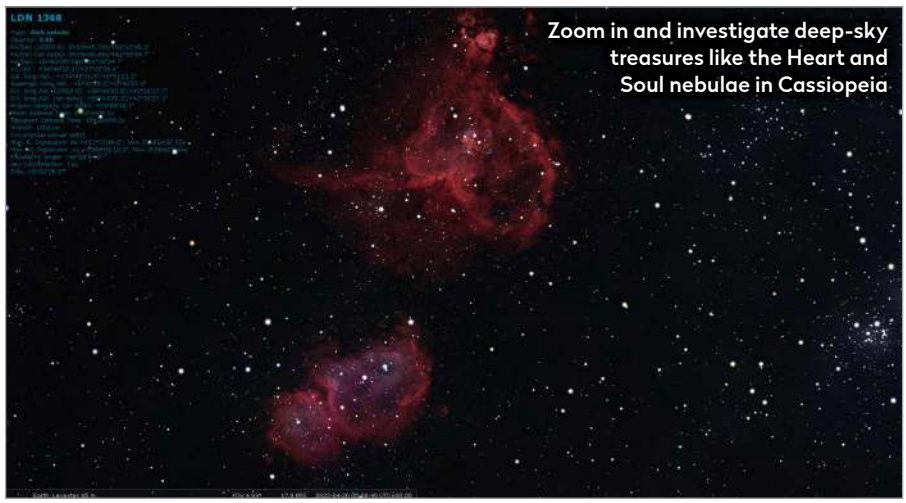
Use Stellarium to track the position of a planet like Venus through the night and day

Stellarium

https://stellarium.org
OS: **Windows; macOS; Linux; web; mobile (Android & iOS)**

Stellarium has been around since 2001 and has evolved into an amazing piece of sky simulation software which runs on Windows, macOS, Linux, web browsers and mobile platforms. Its slightly clunky interface gives access to its multitude of settings and configuration options. Keyboard shortcuts give you control over the appearance of things like horizon, atmosphere, constellation lines, meteor showers and the rate of time progression.

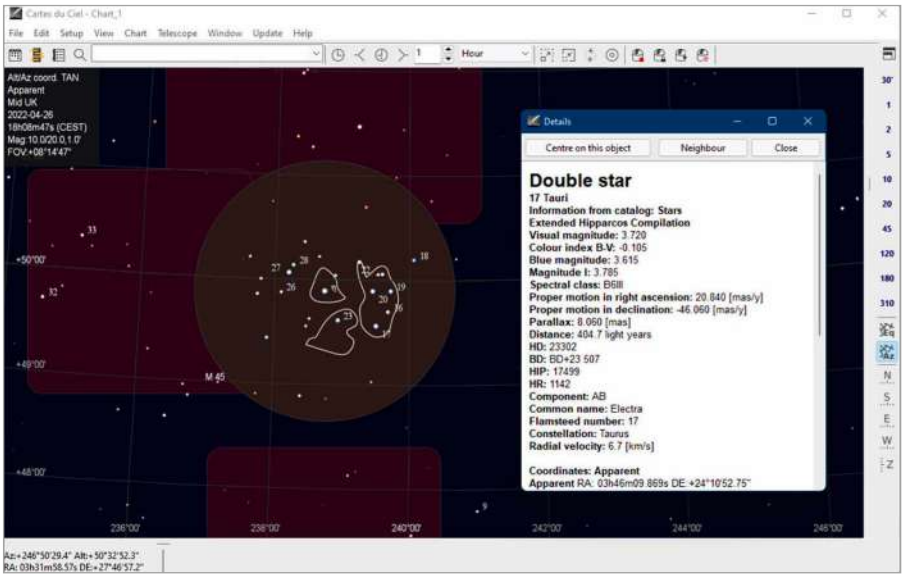
Stellarium is designed to produce a realistic sky and there are numerous projection options, some of which can be used with planetarium projectors. Additional data files can be downloaded to augment the program's capabilities. For example, it's possible to download extended star catalogues capable of showing stars down to mag. +18.0 (in v0.9.0).



Zoom in and investigate deep-sky treasures like the Heart and Soul nebulae in Cassiopeia

Locating objects in the sky can be done manually or via a search interface. Once located, it's then possible to zoom in to the object and see it magnified. In the context of Solar System objects this means you can simulate the view, for example, of a planet at a certain date and time.

Stellarium is highly configurable and it's well worth spending some time exploring the scripts and plug-ins section under the configuration window, as well as the multitude of downloadable material from the Stellarium website (**https://stellarium.org**). Telescope control is also available via the ASCOM platform interface. ▸



◂ **Cartes du Ciel generates sky charts without over-complicating the process**

Cartes du Ciel

www.ap-i.net/skychart/en/start
Download: **www.ap-i.net/skychart/en/download**
OS: **Windows; macOS; Linux**

While Stellarium attempts to simulate a realistic view of the night sky, Cartes du Ciel is more chart-oriented. The program generates accurate charts of any part of the sky, plotting the positions of major and minor Solar System objects, the extensive list of which includes many of the fainter moons of the gas and ice giants.

There are many configuration options to this freeware, including different projection settings, which can all be adjusted to give you the chart you need. Telescope control is a major feature of this program, connecting to your mount via either the separately available ASCOM and INDI protocols (both open source and free).

Majoring on accuracy, Cartes du Ciel also supports the latest GAIA EDR3 star catalogue, which provides positional and physical data on approximately 1.8 billion objects brighter than mag. +21. A nice feature is the ability to request a Digitised Sky Survey (DSS) image of the region covered by the chart. This allows you to view the chart representation and then see an image of that region of sky overlaid with the chart information.

If you're an active observer who likes to plan ahead, Cartes du Ciel is a great package to become familiar with.

Also consider

Celestia A 3D space simulator
https://celestia.space

Aladin An interactive sky atlas
https://aladin.u-strasbg.fr

C2A Planetarium software that builds detailed stellar fields
www.astrosurf.com/c2a/english

WWT An interactive planetarium
www.cfa.harvard.edu/research/worldwide-telescope-wwt

Home Planet Planetarium software with artificial software tracking
www.fourmilab.ch/homeplanet

WinStars Planetarium software that uses the Gaia DR2 star catalogue
https://winstars.net/en

Image processing freeware

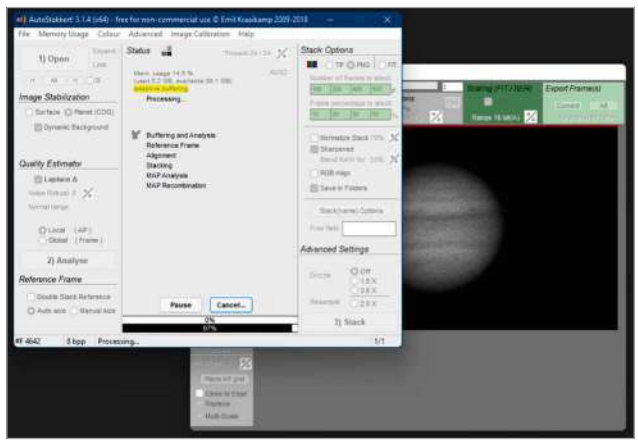
Image processing software simpli es getting the best out of your image capture sessions. These freeware programs will do that for no cost

AutoStakkert!

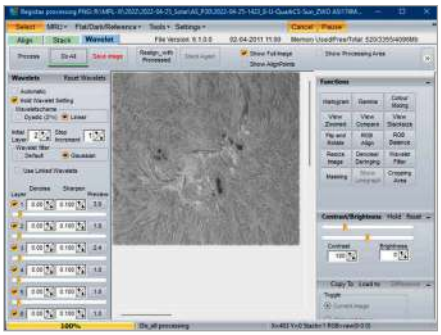
www.autostakkert.com
Download: **www.autostakkert.com/wp/download/**
OS: **Windows; Linux/macOS (with Wine)**

'Lucky imaging' is the process of taking hundreds or thousands of images of a Solar System object with a high frame rate camera, extracting the best frames, aligning them and averaging them together. AutoStakkert! is the current king of registration-stacking software, automating the process and offering the ability to apply it to small sections of an image. It seamlessly combines the results into a single result that is many times smoother and better defined than the individual frames that were processed.

The program's interface appears daunting at first, but is quite simple to use. Once the high frame rate images have been loaded, typically as a movie file in either AVI or SER format, all that you're required to do is click 'Analyse', wait for the program to sort through all of the frames, set your alignment points either manually or automatically, and hit the 'Stack' button. It has never been easier to distil so many source files into a single, high-quality image.



▲ **The program seamlessly combines frames into one image**

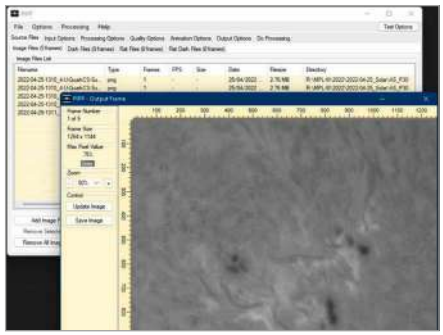


▲ **RegiStax excels at wavelet adjustment, an advanced form of image sharpening**

RegiStax

www.astronomie.be/registax
Download: **www.astronomie.be/registax/download.html**
OS: **Windows; Linux/macOS (with Wine)**

RegiStax used to be the high frame-rate processing go-to application and, although largely usurped by AutoStakkert!, it still maintains a useful place in the realm of Solar System image processing. Where it shines is in its wavelet sharpening module, which involves an advanced form of image sharpening. This can address different levels of detail within an image, from fine to coarse. A processing workflow often involves finishing touches in RegiStax.

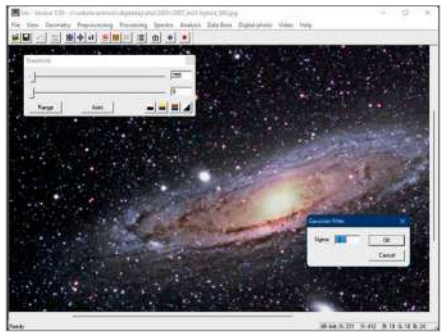


▲ **Images can be automatically centred and cropped for the next processing stage**

PIPP

https://sites.google.com/site/astropipp/home
Download: **bit.ly/3KmjXuU**
OS: **Windows; Linux/macOS (with Wine)**

PIPP (Planetary Imaging Pre-Processor) is a powerful program that can be used to prepare high frame rate sequences for registration-stacking processing. But there's much more to PIPP. For example, if you were to capture a number of images of NLCs using a conventional camera, it's possible to pass these images through PIPP to create a time-lapse animation. The myriad of settings and processing options makes this a powerful addition to your astronomical imaging toolkit.



▲ **IRIS may take more time to get to know, but it has a wealth of powerful features**

IRIS

www.astrosurf.com/buil/iris-software.html
OS: **Windows**

IRIS sits at the more technical end of the image-processing spectrum, but if you take time to learn how to use it properly, you'll have an immense amount of image processing power at your fingertips.

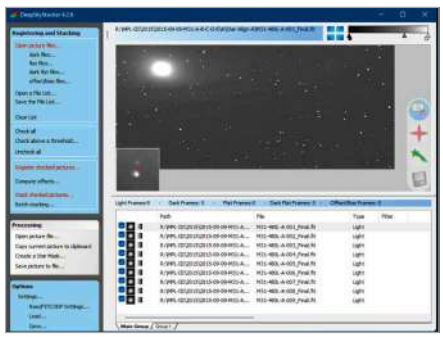
Some of the highlights include: the ability to re-project deep-sky images onto a common projection to remove frame distortion; planetary deconvolution functions to help remove factors which degrade an image; image gradient removal routines; and cometary image-stacking functions.

DeepSkyStacker

http://deepskystacker.free.fr/english/index.html
OS: **Windows**

DeepSkyStacker is similar in functionality to AutoStakkert! and RegiStax, except that it's geared towards the registration and stacking of deep-sky images. Images of deep-sky objects like galaxies or nebulae need special handling before they are combined, a process known as image calibration. This may involve subtracting dark frames to remove hot pixels, bias calibration to remove any residual sensor signals, or flat-field calibration to remove unwanted issues in the optical train. The program automates much of this processing.

There is also a 'Comet Stacking' mode.



▲ **The program's forté is processing deep-sky images of galaxies, nebulae and comets**

The fact that comets move against background star fields is problematic, so the program includes functions that can isolate the stars from the comet in each frame, allowing them to be processed separately before being recombined.

Also consider

FastStone Image Viewer A feature-rich image viewer with processing tools, batch conversion and more
www.faststone.org

PHD2 Autoguiding software suitable for beginners and experts alike
http://openphdguiding.org

FireCapture High frame-rate image capture software
www.firecapture.de

SharpCap Image capture software (Pro version costs £12/year)
www.sharpcap.co.uk

GIMP A Photoshop-like layer-based graphics editor
www.gimp.org

We hope you've enjoyed being introduced to these excellent astronomical freeware packages. Free software has the potential to enhance your astronomical experience hugely, elevating what's possible when you merge modern computers with one of the oldest observational sciences going. Many have an option to donate to the developers who create and support them; if you do find you use freeware regularly we hope you will consider a contribution, however small!

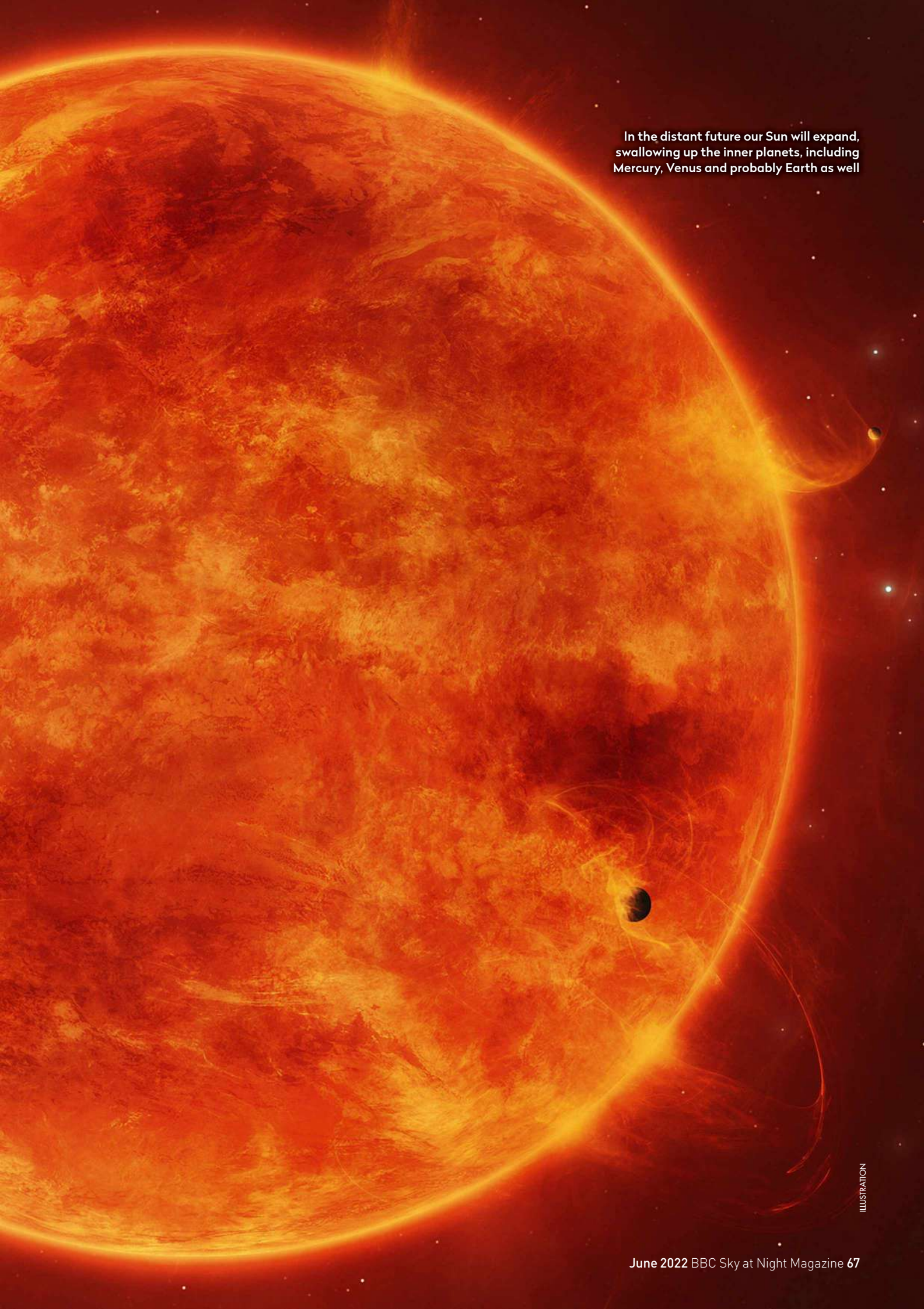
Seeing the Solar System's future

Recent observations offer clues about whether the planets will survive our Sun's far-off fate of swelling out into the Solar System as a red giant. **Colin Stuart** investigates

All good things must come to an end, even stars. Eventually, all stars – including the Sun – will die and the Universe will fade to black forever. For now, our star is able to persist by constantly churning hydrogen into helium. This process, called nuclear fusion, creates enough outwards pressure to resist the relentless force of gravity trying to collapse the Sun into oblivion.

Currently, the Sun is getting through 600 million tonnes of hydrogen every single second and there will come a time when there is no hydrogen left to burn. Despite its voracious appetite for this abundant element, astronomers estimate that the Sun has about 5 billion years' worth of fuel left. Once the hydrogen is exhausted, gravity will win and the Sun's core will begin to collapse. With solar material now considerably more compressed, the temperature in the core will climb to a staggering 100 million degrees. That compares to the 15 million degrees you'll currently find in there. Meanwhile, the pressure will reach over a trillion times the atmospheric pressure here on Earth. ▸

STOCKTREK IMAGES/TOMASZ DABROWSKI/ISTOCK/GETTY IMAGES



In the distant future our Sun will expand, swallowing up the inner planets, including Mercury, Venus and probably Earth as well

ILLUSTRATION

For decades, astronomers have wondered about the true effect of a Sun-like star's death on its system of planets and moons

▸ Such crazy temperatures and pressures mean that helium becomes the ingredient rather than the product, and it gets pressed into carbon and oxygen. The Sun will get through the equivalent of 10 Earth masses of helium every second. This 'helium burning' happens at a much faster rate than the previous slow-and-steady hydrogen-burning phase. The delicate balance within the Sun is now upset the other way. The outwards pressure is so great that it trumps gravity and the Sun begins to bloat into a red giant. It will eventually swell to swallow Mercury and Venus, and it may engulf Earth as well.

The Sun's final death throes will then see it eject its outer layers into space like a snake shedding its skin. Astronomers call the beautiful, glowing and nested shells of gas this creates a planetary nebula. Nestled at its centre will be a white dwarf – a ball of carbon and oxygen the size of Earth. Indeed, this is all that will remain of the Sun's once mighty core.

For decades, astronomers have wondered about the true effect of a Sun-like star's death on its system of planets and moons, in particular whether any planets can survive the onslaught. Now, at last, we have some idea thanks to a breakthrough discovery.

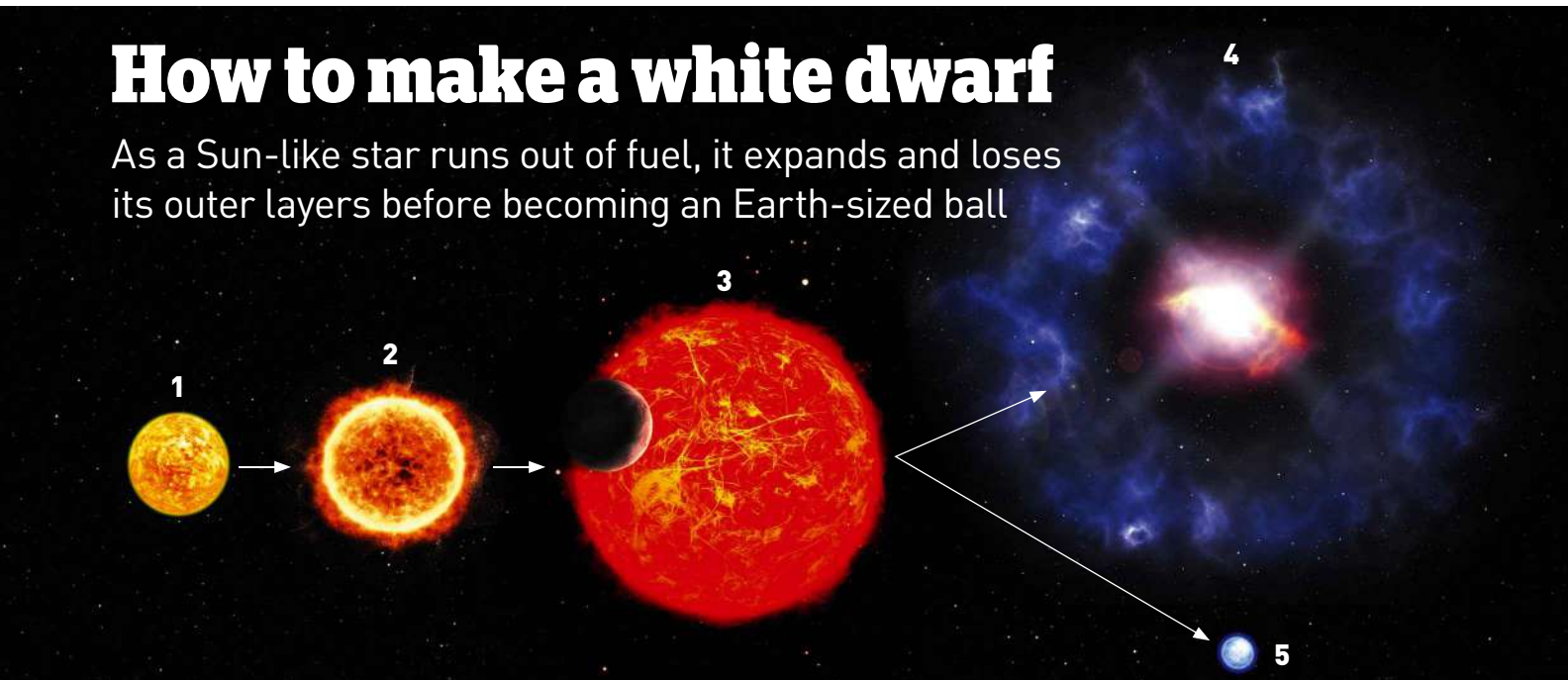
Clues to our Solar System's fate

A team led by Joshua Blackman, from the University of Tasmania, Australia, recently found a Jupiter-like planet swirling around a white dwarf close to the centre of our Milky Way Galaxy. "The system we've discovered is a glimpse into the possible future of the Solar System," says Blackman. While the dying Sun will likely take out the terrestrial planets, the outer planets could well survive. "This is the first time

GETTY X 5, MARK GARLICK X 2

How to make a white dwarf

As a Sun-like star runs out of fuel, it expands and loses its outer layers before becoming an Earth-sized ball



1. Burning hydrogen
A Sun-like star is powered by nuclear fusion, which turns hydrogen into helium with the release of energy. This can go on for around 10 billion years. During this time it is said to be a 'main sequence' star.

2. Shell burning
A star is said to move off the main sequence when it transitions from burning hydrogen to fusing helium. This often happens in layers surrounding the dead core and so astronomers refer to it as 'shell burning'.

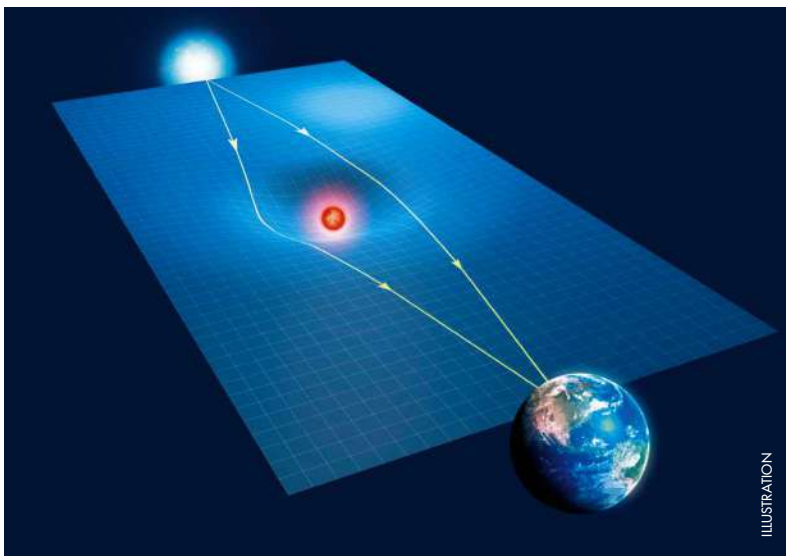
3. Red giant
The star gets through its helium one hundred times faster than it did its hydrogen. This creates huge amounts of outwards pressure and it surges out into its planetary system. Its surface would reach out to about where Earth is now.

4. Planetary Nebula
Helium burning is unstable. It sends shockwaves through the star and convulsions shake it apart. A few of these events, each 100,000 years apart, create nested shells called a 'planetary nebula'.

5. White dwarf
A core of carbon and oxygen – the products of helium fusion – is left at the centre. Astronomers refer to this as a white dwarf and it contains about half the mass of the original star packed into an Earth-sized ball.

Scientists have located a Jupiter-like planet orbiting a white dwarf near the Milky Way's centre. Its orbit takes it twice as close to its star as Jupiter is from our Sun

ILLUSTRATION



ILLUSTRATION

▲ **'Gravitational microlensing' can be used to view otherwise unobservable objects. Here, light from a blue star (top) is bent as it passes through the gravitational field of a star (centre)**

one of these planets in a similar orbit to Jupiter has been found," he says.

Blackman made this important discovery using a technique called 'gravitational microlensing'. "The gravity of the white dwarf and its companion planet acts like a magnifying glass," Blackman says. "It bends the light from a more distant star and makes it appear brighter to observers here on Earth."

However, for this to happen, there has to be a near perfect alignment between the foreground 'lens' and the background star. According to Blackman, the chances of the right alignment are "one in a million". So, to boost their chances of seeing it, they looked towards the centre of the Milky Way where stars are huddled more closely together. Observe enough background stars and a rare alignment becomes almost guaranteed.

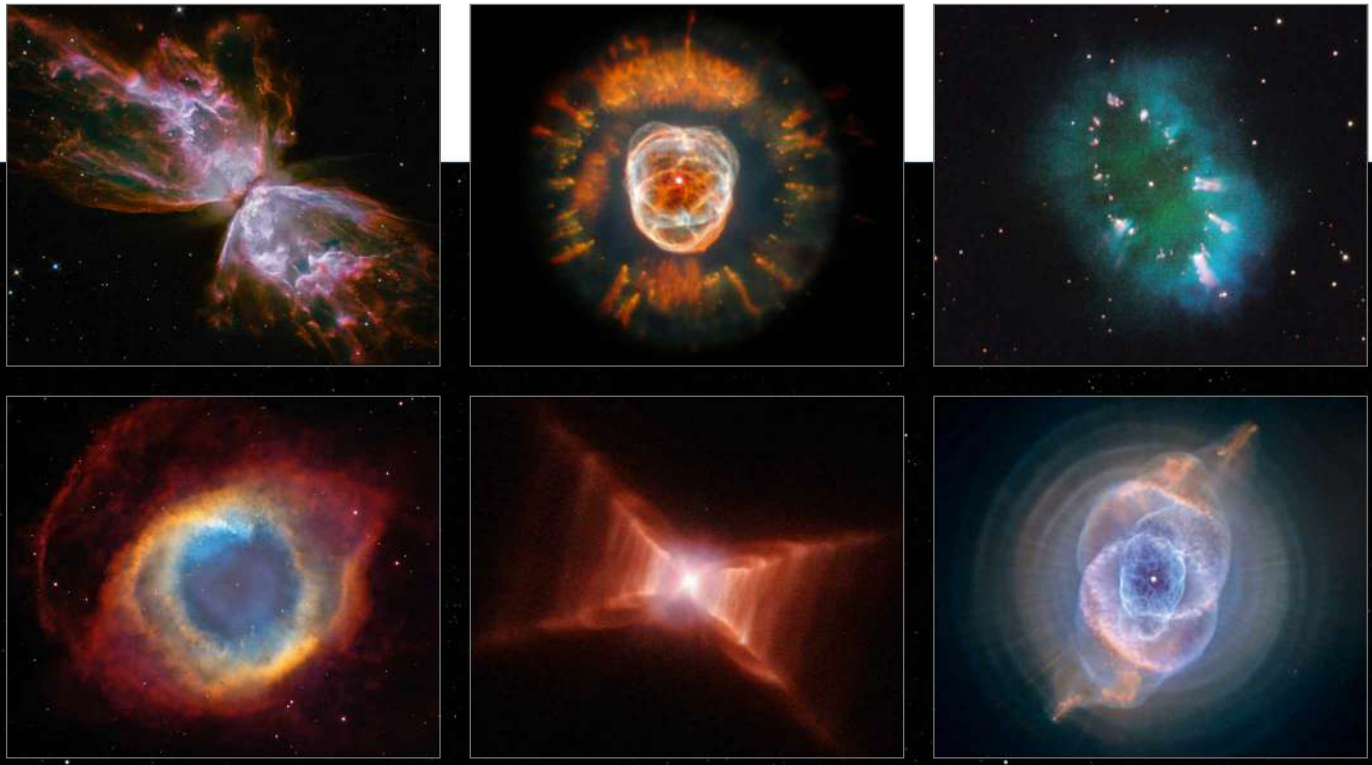
This is a unique way to look for alien worlds because the two leading methods rely on seeing changes in the light of the host star. Either the star gets dimmer when a planet ghosts in front of it, or we see changes in the starlight caused by the star wobbling due to the gravitational pull of an otherwise unseen planet. Removing the need to see the star's light opens the door to finding more weird and wonderful worlds like those swirling around dead stars.

Object of mystery

In fact, the team wasn't actually looking for planets around dead stars at all. Instead, they were searching for worlds circling ordinary stars in the prime of their lives. This particular microlensing event was seen way back in 2010 and Blackman recently reanalysed the data. The amount of lensing suggests the star has a mass between 15 and 93 per cent that of our own Sun. Then Blackman used the Keck Observatory in Hawai'i to take a closer look, but he was in for a shock: there was nothing to see. The lensing had told them that an object with the mass of a small star was there, but it was seemingly invisible.

"We were puzzled and spent quite a few years trying to explain the discrepancy between our expectation and what we observed," says Blackman. "Eventually we worked out that the reason we do not see the star is because it's too dim to see." They were able to rule out other dead stars like black holes and neutron stars. "It has to be a white dwarf," Blackman says.

The white dwarf magnified the light from a background star, but that light was warped by the presence of a planet in tow. The amount of warping told Blackman how massive the planet is. This particular planet is 40 per cent more massive than ▸



▲ No two planetary nebulae are the same. Clockwise from top left: the Butterfly Nebula (NGC 6302), Eskimo Nebula (NGC 2392), Necklace Nebula, Cat's Eye Nebula (NGC 6543), Red Rectangle Nebula and Helix Nebula. What will the Sun's planetary nebula end up looking like?

Red giant to planetary nebula

Despite the name, planetary nebulae are blown out by dying red giant stars

Astronomers are pretty confident of the Sun's fate because the Universe is littered with similar cosmic tombstones. The Cat's Eye Nebula, in Draco, is perhaps the most famous example of these so-called 'planetary nebulae'. They are about a lightyear across (a quarter of the distance from the Sun to the next nearest star).

It's worth saying that the name planetary nebulae is a terrible one. When early astronomers, armed with primitive telescopes, first stumbled upon them they thought they looked like planets. Today we know better, but the unhelpful name has stuck around.

Planetary nebulae themselves, however, do not stick around for long. They are initially bright because they are lit up by intense ultraviolet light from the dying star. Yet this is only enough to sustain a planetary nebula for a few tens of thousands of years. Eventually it will fade and the intricate grave-marker will disappear from view.

No two planetary nebulae are quite the same either. Sometimes they are roughly spherical, but at other times have a distinct split appearance. The reasons for these unique shapes aren't entirely clear, but it's thought to have a lot to do with how the magnetic field of the star gets shaped and moulded as it perishes.

It could be that one day, billions of years from now, an alien race will look across the stars and see a glowing ball of gas that is all that remains of our Sun.

▸ Jupiter and it orbits the white dwarf approximately twice as close as Jupiter circles around the Sun.

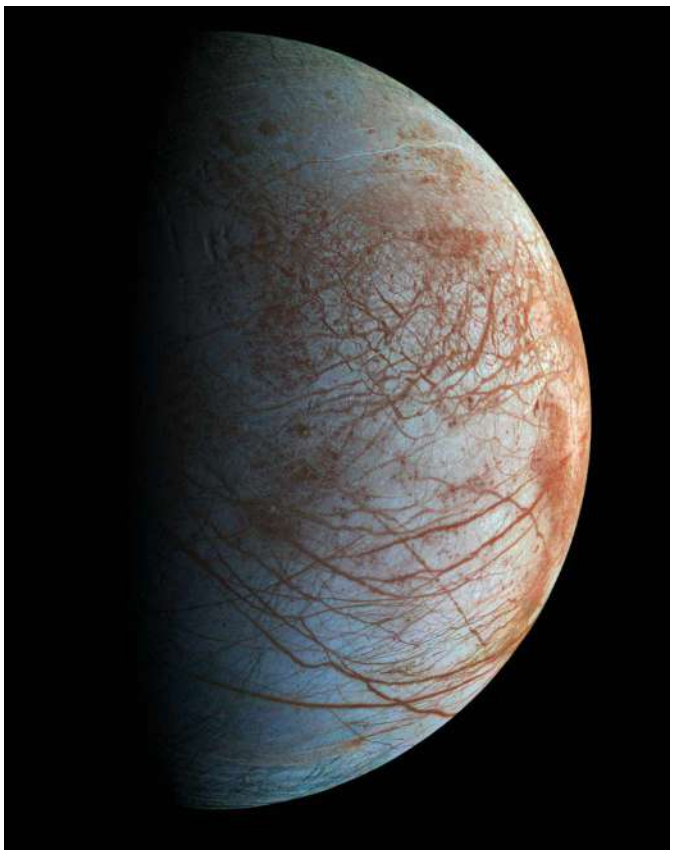
According to Blackman, such proximity meant it was touch and go whether the planet would survive the death of its star. "It only needed to be slightly closer to its host star to be disrupted during the star's giant phase," he says. "But the planet survived because it was at a large enough orbit."

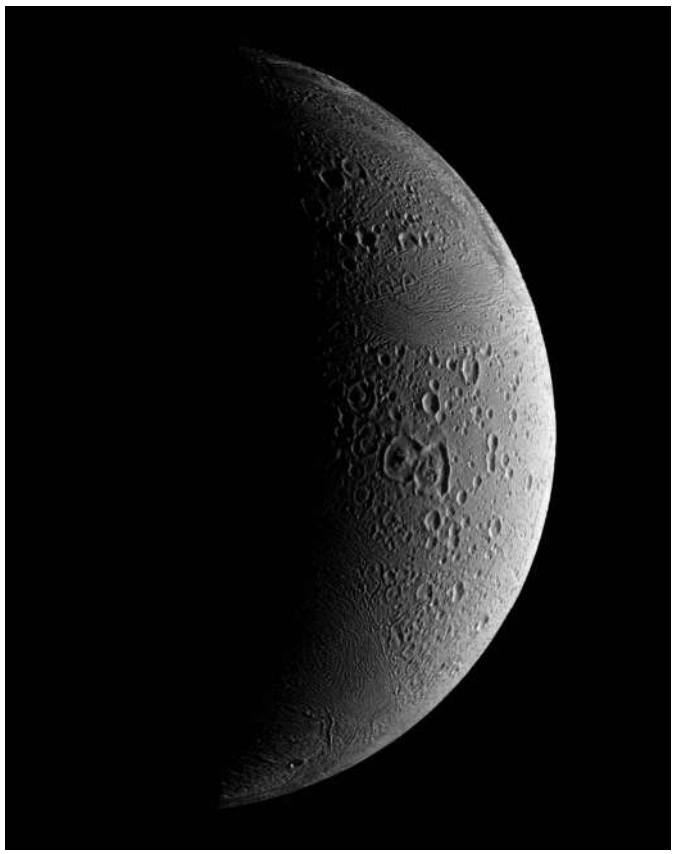
"It's a very exciting discovery," says Thea Kozakis, from the Technical University of Denmark. "Since there are so few known planetary systems around white dwarfs, every planet gives so much insight," she says.

We may not have to wait too long for the floodgates to open and more discoveries like this to come pouring in. The Nancy Grace Roman Telescope, due for launch in 2027, will be able to directly image giant planets around white dwarfs close to the centre of our Milky Way. For the first time we'll have a more complete census of these cosmic survivors

The Nancy Grace Roman Telescope will be able to image giant planets around white dwarfs near the Milky Way's centre

ILLUSTRATION





▲ **With their icy shells melted by an expanding red giant Sun, Jupiter's moon Europa (left) and Saturn's Enceladus could be a temporary refuge for life-forms fleeing from Earth**

and we will start to learn so much more about the future of our own Solar System. In particular, we will learn whether planets like these are the lucky few, or whether it's common for Jupiter-like planets to survive their stars being extinguished.

Kozakis says that these enduring gas giants are a compelling idea because the death of their stars could turn their moons into potentially habitable worlds. Astronomers often talk about a 'habitable zone', a region around a star where the temperature is just right to permit the existence of liquid water. An expanding, dying star will shift this region considerably further out.

Revealing water worlds

In our own Solar System, for example, Jupiter and Saturn currently have icy moons, such as Europa and Enceladus. In fact, according to Kozakis, approximately 99.9 per cent of the Solar System's water lies beyond the realm of the terrestrial planets.

In particular, we will learn whether it's common for Jupiter-like planets to survive their stars being extinguished

"During the red giant phase it is possible that the increased luminosity of the host star can melt the icy shells of these frozen water worlds, revealing the liquid water oceans that lie beneath," she says.

It could offer our descendants a stay of execution. "[Whatever forms of life that are] still around in five billion years would likely have a better chance of survival if it moved to one of Jupiter's moons," says Blackman.

It would, however, only be a temporary reprieve. "White dwarfs start off extremely hot and then cool off over time due to the lack of an internal heat source," says Kozakis. "This means that the traditional habitable zone will slowly move inward towards the white dwarf over time." Eventually, you would need to be one hundred times closer to the white dwarf than Earth currently is to the Sun in order to keep warm. An unusually hot white dwarf could relax this constraint, but then it would also give off huge amounts of radiation that life would struggle to deal with.

Ultimately, unless you are planning to move away from the Solar System, the death of our star is inescapable. Everything comes to an end, so it's best to enjoy things while they last.

Colin Stuart (@skyponderer) is an astronomy author and speaker. Get a free e-book at **colinstuart.net/ebook**

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The fundamentals of astronomy for beginners

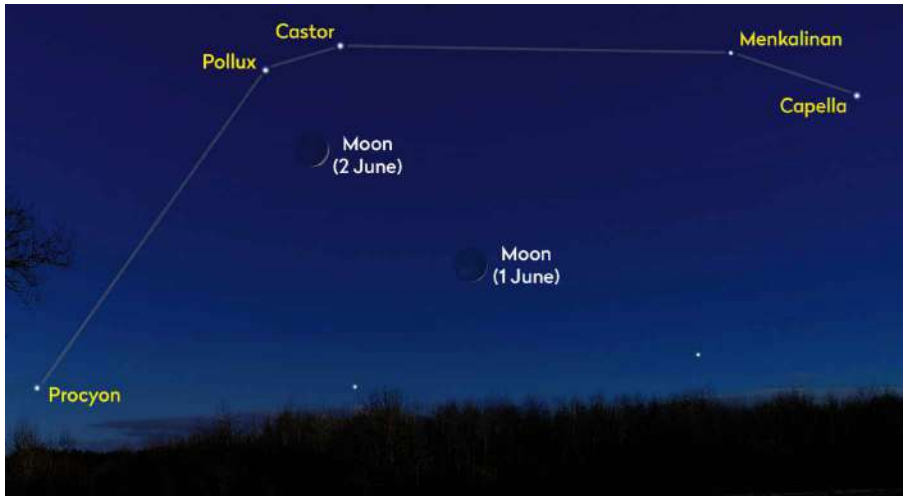
EXPLAINER

Spend a month with the Moon

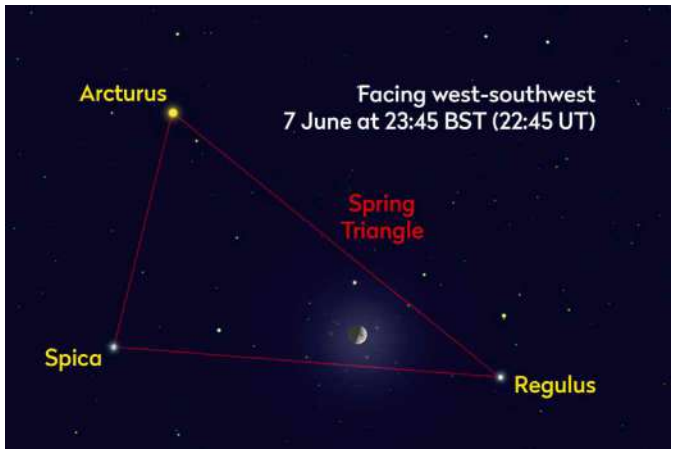
Scott Levine follows Earth's natural satellite and jumps off to spot nearby targets

We all need some help when we're new to the skies. Fortunately, we have an incredibly handy tool to guide us on our way: the Moon. As it orbits and its phase changes, we can use it to hop off to the amazing objects it passes on its way. So use this article as inspiration this month, as you head outside and let the Moon guide you through the night.

Most of what we will talk about here are objects we can see with the unaided eye, but we'll visit some deep-sky objects too. Before you start, however, remember to give your eyes time to adjust to the dark and preserve your night vision with a red filter on a torch, or by using a mobile phone's night mode. Now we are ready, let's get started on our month's tour with the Moon!



▲ **1 June: look for a thin crescent Moon under an arch of five stars above the western horizon**



► **7 June: the first quarter Moon appears in the Spring Triangle, with Arcturus marking the asterism's top corner**

New to first quarter Moon

The Moon was at its new phase on 30 May, lying between the Sun and Earth, which means that as June gets underway it starts to leave the Sun's glare. On 1–2 June, you will find an eyelash-thin crescent under five stars arching just above the western horizon. With the summer solstice only about three weeks away, twilight lingers deep into the evening, so these may be tough to see.

From left to right (south to north), they are Procyon (Alpha (α) Canis Minoris), Pollux (Beta (β) Geminorum), Castor (Alpha (α) Geminorum), Menkalinan (Beta (β) Aurigae) and Capella (Alpha (α) Aurigae). Sound familiar? In the cold parts of the year, we're used to seeing them along the left-hand edge of the Winter Hexagon, but the seasons have whittled them down to this subtle and delicate arch. This part of the sky is the opposite direction to the galactic centre: as we look towards the Moon, our gaze races through the twilight and off into the vast emptiness of the open Universe.

Let's see if we can spot the first quarter Moon in the south in the late afternoon on 7 June (see box 'Viewing the Moon in the day'). After sunset, the Moon appears to be about halfway between the stars Spica (Alpha (α) Virginis) and Regulus (Alpha (α) Leonis), within the sprawling Spring Triangle. Try to spot orange-red Arcturus (Alpha (α) Boötis), the third of the Triangle's corners, northeast of the Moon.

Full Moon and Sagittarius

Look for June's full Moon on the 14th in Sagittarius, where the brightest of the Archer's stars form its famous 'Teapot' asterism. It's about two weeks – about half a lunar orbit – since we saw the Moon near the galactic anti-centre. Now, we're facing inwards, towards the Galaxy's centre, which is thousands of lightyears behind the Teapot's spout. A few Messier

CHARTS BY PETE LAWRENCE, CLEUSA SANTOS/EYEEM/ISTOCK/GETTY IMAGES

objects are in this part of the sky, including the Butterfly and Ptolemy Clusters, M6 and M7, and the Lagoon Nebula, M8, but the full Moon makes them tricky to see.

Waning Moon and planets

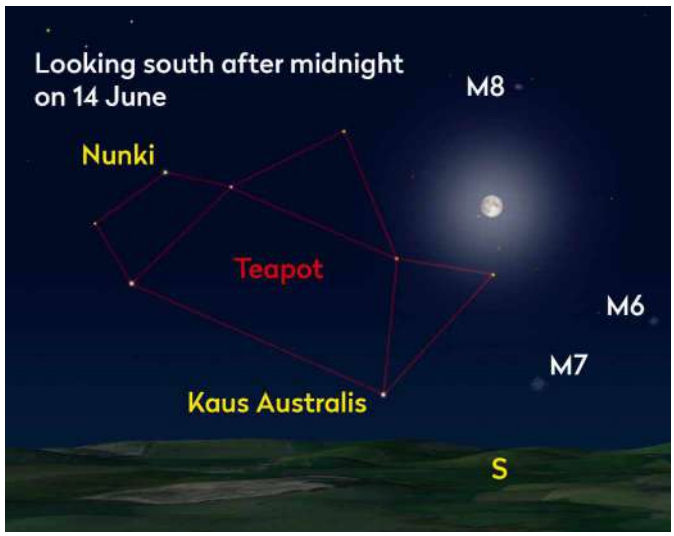
After full Moon, its late-night, waning phases begin. Over the next few nights the Moon meets up with four of our Solar System's bright planets: on 18–19 June it glides past Saturn; and then, on 21 June, on the night of the summer solstice, the last quarter Moon shines with Jupiter. From there, it meets Mars in the morning twilight on the 22nd, and a whisper-thin crescent greets Venus on the 26th.

We see these conjunctions because the planets all orbit the Sun in roughly the same plane, which we see as a path across the sky called the ecliptic. The ecliptic also represents the Sun's path across the sky. The Moon's orbit is tilted by 5° relative to the ecliptic, so the Moon usually appears to pass near the Sun and planets, but only blocks them out from time to time.

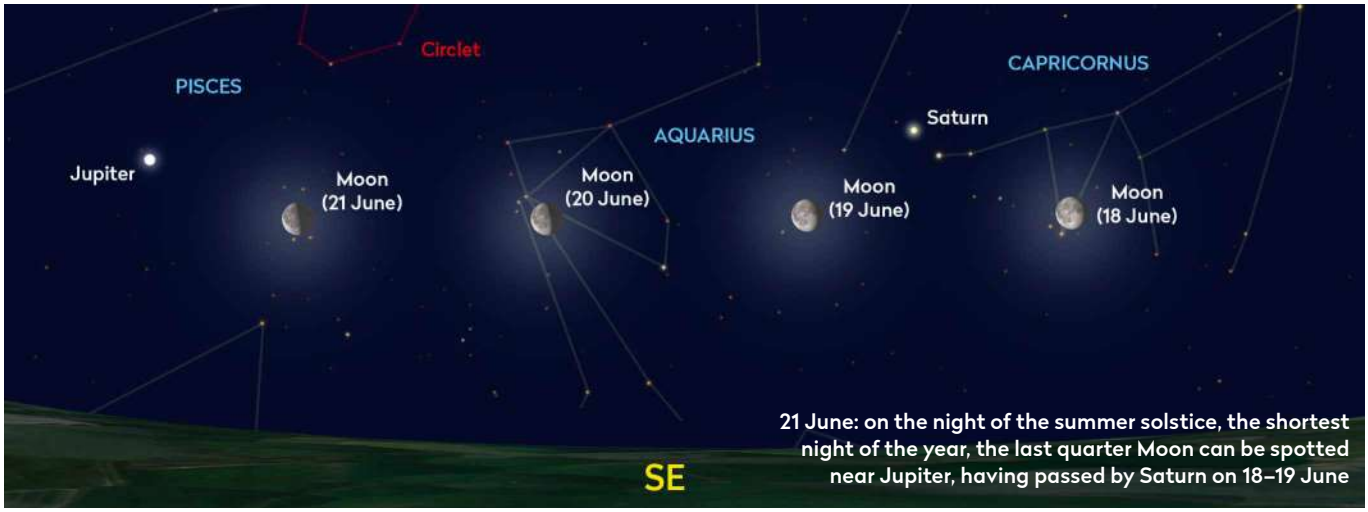
The Moon is new again on 29 June. So, we've made it all the way back to where we started, ready to see what July brings.

We hope you'll enjoy using our nearest neighbour as your guide as you discover some amazing sights in the night sky.

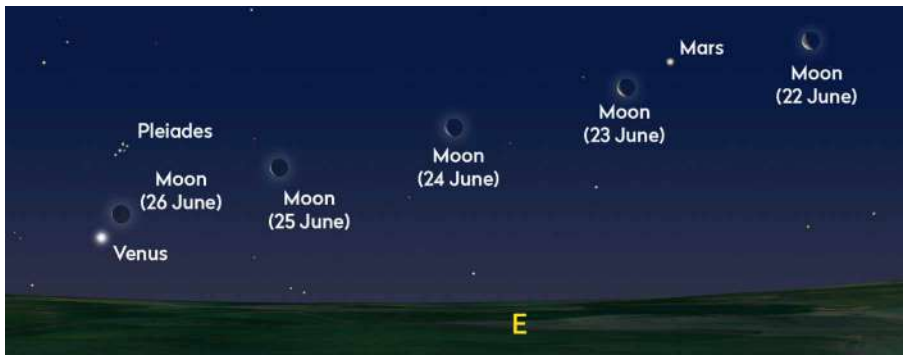
Scott Levine is an astronomy writer and naked-eye observer based in New York's Hudson Valley



◄ 14 June: the full Moon is now near the Teapot asterism, its brightness making nearby deep-sky objects tricky to spot



21 June: on the night of the summer solstice, the shortest night of the year, the last quarter Moon can be spotted near Jupiter, having passed by Saturn on 18–19 June



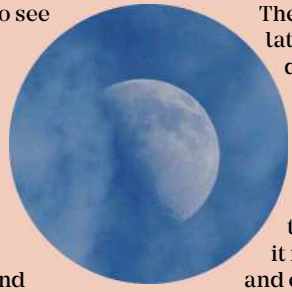
▲ 26 June: look for a thin crescent Moon near Venus and the Pleiades, M45, after it has appeared close to the Red Planet on the morning of the 22nd

Viewing the Moon in the day

Top tips on spotting the Moon's phases in daylight hours

We often think the Moon is a fixture of the night, but we can also see it during the day. Since the Moon travels all the way around Earth as it orbits, it spends half its time on Earth's daytime side.

We can see all the phases during the day, but it's easiest to start around first quarter (7 June). This phase rises around noon and sets around midnight, so we'll see it towards the south in the late afternoon.



The Moon rises 50 minutes later each day, and inches deeper into the night before it slides into the early mornings. Last quarter phase (21 June) sees it due south in the mid-morning.

Spotting a full Moon in the day is tricky because it rises around sunset. Try and catch it just before it sets around sunrise.

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Detect exoplanets from your back garden

Use the 'transit method' to capture and plot a distant star's dimming caused by a nearby world

Exoplanets are planets that orbit stars other than the Sun. It's incredible to think that before 1992 it was still uncertain whether exoplanets existed. Today, the number of known exoplanets is just over 5,000 and this total is increasing each day. Here, I will show you that even amateurs can detect these faraway worlds from their back gardens.

There are several indirect ways by which exoplanets are found, as only a handful have been directly observed by very large telescopes. By far the most productive method is known as the 'transit' method, which works as follows. If there is a planet orbiting a star in such a way that the planet passes in front of the star as seen from Earth, the light from the star will dim by a small amount. The graphic (right) illustrates the dimming effect produced by the transit.

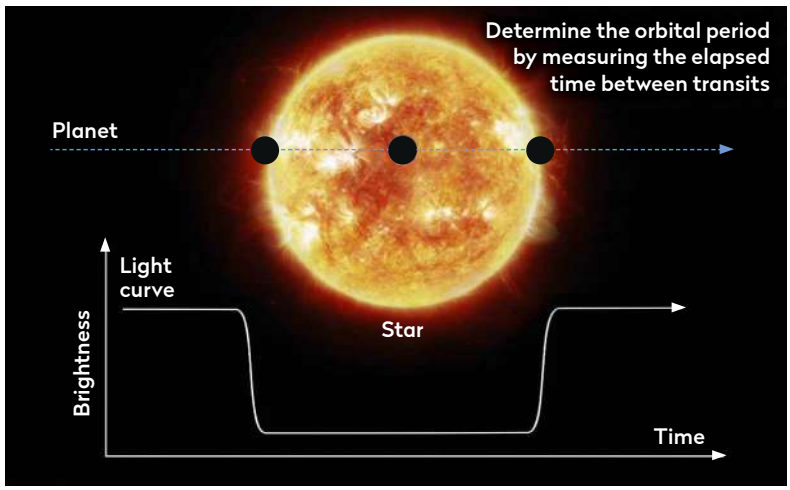
It is within the capabilities of amateur astronomers to measure this dimming and to detect the existence of this unseen body. The amount of dimming is important because it is tiny and often quoted in millimagnitudes. However, there are many exoplanets you can hunt down with dips in the light curve of 20 or 30 millimagnitudes, which is within the capabilities of an amateur. For example, in a four-hour run of 45-second exposures, where I captured a system called KELT-23A with an exoplanet called KELT-23Ab, the dip depth was 20 millimagnitudes (see 'More Online' box for more details).

Here, I'll look at the basic process you need to follow. First, select a host star and a transit event and then capture images of it from before the start (the ingress) until after the end (the egress). You'll need to choose an exposure so that the star will not saturate the camera detector, but will give a good signal above background noise (unwanted artefacts). You can experiment by viewing the images in a software program that will show the brightness of the pixels.

When the event has been recorded, you need to use one of many software packages to perform a process called 'aperture photometry' on each image to come up with a brightness, or magnitude value of the star in each image. Note that you will need calibration frames for your detector with good flat frames being important for high accuracy. Calibration frames are vital: good flats reduce image gradients and help with checking brightness measurements against fixed-brightness stars.

More software can be used to plot the resulting light curve in which you hope to see the transit event.

Finally, check your PC clock is accurate and you too can detect a planet orbiting another star!



ESA, EXOPLANET TRANSITING DATABASE

Ian Sharp is based in West Sussex and has been an amateur astronomer for over 50 years

MORE **ONLINE**

Download a graph showing the author's capture of exoplanet KELT-23Ab. See page 5 for instructions

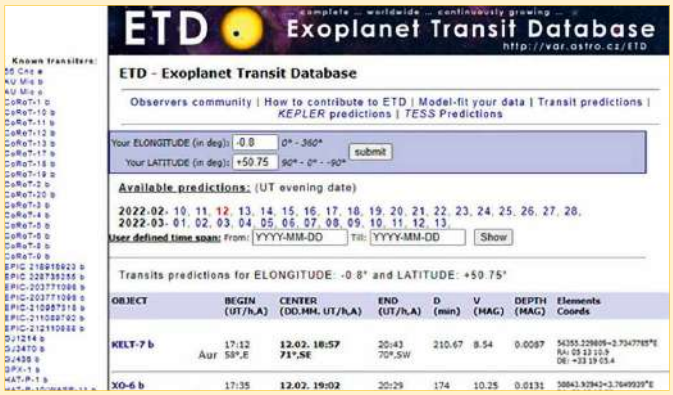
What you'll need

- A polar-aligned mount capable of tracking the stars. Autoguiding is useful, but not mandatory as a typical exposure is around a minute; less for the brighter host stars.
- You can use whatever telescope you have! Smaller apertures can still work when trained on brighter host stars.
- A detector; the best is a cooled mono CCD camera with filters. CMOS cameras are fine and a DSLR will also get the job done.
- Use image capture software of your choice, as long as it will take a sequence. Save in FIT format as this can be read by photometry software.
- Software for the photometry and plotting: there is plenty to choose from, including AstroImageJ, which is free (**www.astro.louisville.edu/software/astroimagej/**) or HOPS software from ExoWorld Spies (**www.exoworldsspies.com/en/software/**) is free.

Step by step

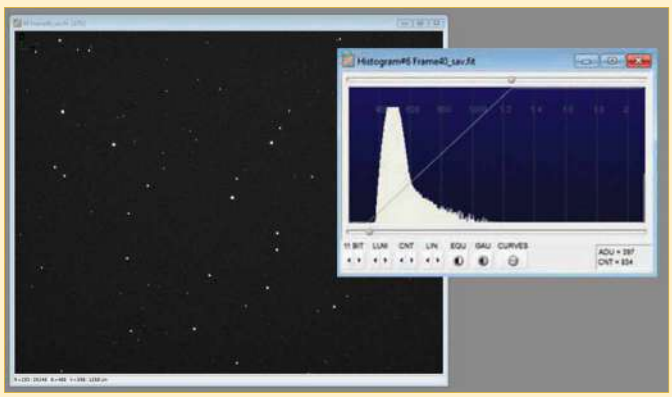
Step 1

To prepare, you'll need a clear night. Try to avoid a very bright Moon, as this will cast a gradient and decrease the accuracy of your photometry. If you have a portable rig, make sure to get it set up and polar-aligned as early as possible.


ETD
Exoplanet Transit Database
ETD - Exoplanet Transit Database
Observers community | How to contribute to ETD | Model-fit your data | Transit predictions | KEPLER predictions | TESS Predictions
Available predictions: (UT evening date)
Transits predictions for ELONGITUDE: -0.8° and LATITUDE: +50.75°
OBJECT
BEGIN (UT/h,A)
CENTER (DD.MM, UT/h,A)
END (UT/h,A)
D (min)
V (MAG)
DEPTH (MAG)
KELT-7 b
XO-6 b

Step 2

To find a target, pick an event by using an online resource such as the Exoplanet Transit Database (**bit.ly/3DrNuBD**). Enter your location and look for an event. The listings show the magnitude of the star and the dip, and how to set up a plan to image the event.

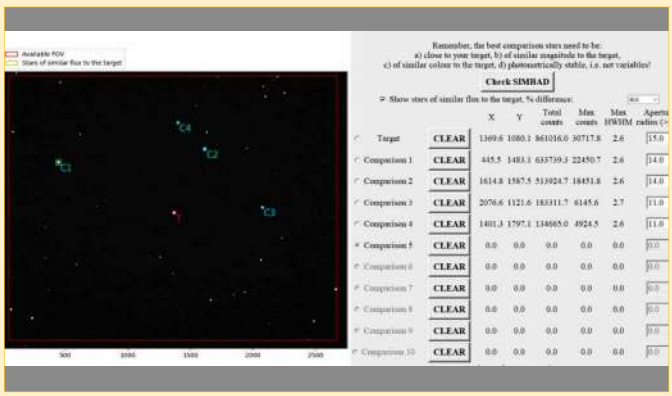


Step 3

Centre on the star (plate-solving will help here) and take a sequence of exposures to cover the expected transit, while allowing at least 30 minutes either side. WASP-35 is the star at the centre of the field of view (above).

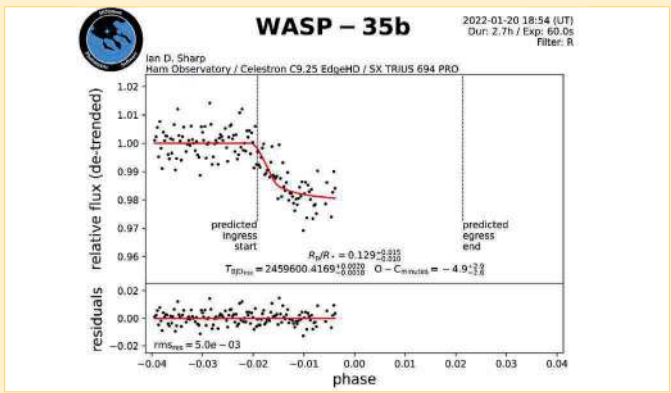
Step 4

You may already have calibration frames, depending on your camera. If not, take bias, dark and at frames. If you are new to this there are plenty of helpful resources. Good at frames are essential in order to obtain the most accurate magnitude values.



Step 5

The next step is to perform the photometry. The software will require you to review the images and choose comparison stars. These should be of a similar magnitude to the target star and not variable. The photometry example (above) is in HOPS software.



Step 6

You can plot a graph on paper, or use the features of software such as HOPS or AstroImageJ (AIJ). The example shows how you can see just the ingress (start) of a transit by exoplanet WASP-35b. The rest was clouded out, but an exoplanet was detected!

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Imaging NLCs on your smartphone

Coax your phone's camera into low-light mode and catch ethereal noctilucent clouds

▲ **In low-light mode your smartphone camera is a powerful ally in the effort to catch elusive NLC displays**

Over recent years, the low-light imaging capabilities of smartphones have improved greatly. It's also encouraging to see manufacturers actively promoting phones based on their performance under low-light conditions. Not all smartphones are created equal of course, and older models may still struggle to grab anything out of the darkness. This is also true of current models, not all of which put a priority on low-light capability.

For those brands which offer good night-time sensitivity, the cameras found on their phones are quite capable of imaging atmospheric phenomena such as the aurora or our 'Capture' subject for this month, noctilucent clouds (NLCs). If present, NLCs can vary in brightness from just about visible to making you wonder how anyone can ever miss them. Bright displays may register using the automatic functions in your phone's camera, while dimmer ones may need a bit of fiddling to get something recorded.

Many smartphones have advanced photographic modes, offered under a 'Pro' setting. These allow you to tweak the camera's settings, adjusting core values such as ISO, exposure time, and white balance. In addition, there are apps available which may offer a better low-light settings interface.

The technology in some phones is truly remarkable, offering processes such as dynamic image-stacking as standard. Here, you can take a multi-second exposure of a low-light scene while the camera is handheld, and the final result is free of hand-shake.

Traditional approach

If you prefer a more purist route, an inexpensive phone mount allows you to attach your smartphone to a standard tripod and carry out long exposures without the worry that you're wobbling the phone or that software is 'adjusting' the end result.

The field of view through most smartphones is wide by default and this is excellent for grabbing NLC displays. Some models allow you to select even wider views, but here you need to be careful that all of the settings and features offered under the 'standard' wide view are also in the super-wide setting. The same is true for narrower field settings that allow you to get closer to the action. Here, it's wise to stick to optical zoom only, avoiding the digital zoom functions. Optical zoom gives you a truly magnified view while digital zoom is a software resize of the image, something you can do yourself once you have downloaded your images to a computer.

File formats are important too and if your camera offers lossless formats for storage, we'd recommend using these, as 'lossy' formats such as JPEG mean that a lot of processing goes on to reduce the file size.

When it comes to NLC displays, the beauty of a smartphone is that it's easy to set up, easy to carry to a preferred observing site, and easy to operate.

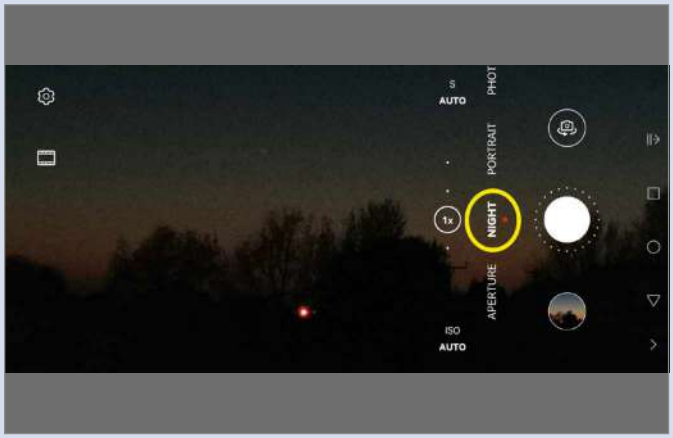
Equipment: Smartphone and holder on a tripod

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

✉ Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step



STEP 1

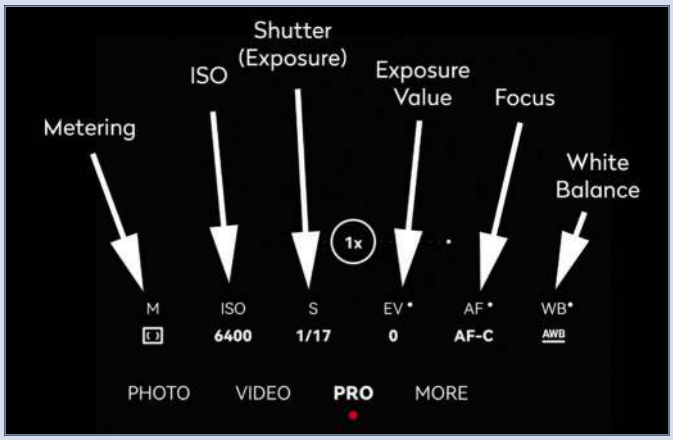
To work out your phone's night-scene imaging capability, try to capture a photo of the night sky under deep twilight and night conditions. Try your phone on automatic mode (some models can detect dim light conditions and adjust), on a dedicated night mode, or switch to manual mode and adjust the settings yourself.

STEP 2

Some cameras have amazing short exposure, registration and stacking functions, which allow you to record a night scene while the device is handheld. The results can be very impressive. Also consider purchasing a low-cost phone holder, which can be mounted on a tripod. Typically costing under £10, a phone holder will ensure your phone is stable for any length of exposure.

STEP 3

Pressing a screen shutter button will probably wobble the camera, but there are a couple of ways around this. You could set the shutter delay function, the one used to take group shots with you in them. Alternatively, you could try wired headphones with a volume control: when these are connected to your phone the volume increase button often acts as a shutter release.



STEP 4

If your phone camera doesn't offer a 'Night Scene' mode, another way may be to adjust the camera's settings using either a 'Manual' or 'Pro' mode, or by using a third-party app to control its settings. Increasing ISO and exposure length are the two main phone adjustments, with the option to manually set the focus at infinity.

STEP 5

If an NLC display appears, identify the brightest part and aim to capture that first. Adjust the camera settings to give you a result that shows detail but isn't too noisy. You may need to reduce the ISO while increasing exposure. If your camera has a non-compressed format, eg non-compressed TIFF, opt to use this.

STEP 6

If you succeed, think how you can add interest to your shots. If there's a body of water nearby, perhaps attempt to photograph NLCs above that and capture their reflection too. As ever, make a note of when and where you took the shots, and consider sending them into an organisation such as the BAA.

APY Masterclass

Framing a dark molecular cloud

How this image of NGC 6729 and cluster NGC 6723 was created

Astronomy Photographer of the Year
2021 shortlisted entrant in the 'Stars and Nebulae' category

▲ **The final image brings out the rich textures of the dark molecular cloud in Corona Australis, NGC 6729 (right) and the detail of the nearby globular cluster, NGC 6723**

ALL PICTURES: PAUL WILSON

The juxtaposition of objects in an astrophoto can make an enticing composition. I used this idea as the basis for my image of the dark molecular cloud NGC 6729 in Corona Australis and globular cluster NGC 6723, just 15 arcminutes distant in Sagittarius, which was shortlisted in the Astronomy Photographer of the Year 2021 competition. Here, I'll explain the steps that helped me create this image.

If you are planning an image like this, the free sky atlas Aladin (**bit.ly/3x5ekhN**) allows you to simulate your main and guide camera's field of view and apply these to provide the desired layout and optimal guide star placement. This is the first step in understanding how your image will look, plus it provides you with the precise astronomical coordinates for the object and camera rotation in degrees.

At this point, I find it helpful to assess the nature of the objects in the field of view and see whether any special filters are required. For NGC 6729, Hydrogen-alpha (Ha) was going to be important to highlight the faint, deep red nebulous colours, while for the natural colours, Red, Green and Blue filters were used. Next, Luminance and Ha were used for the final resolution.

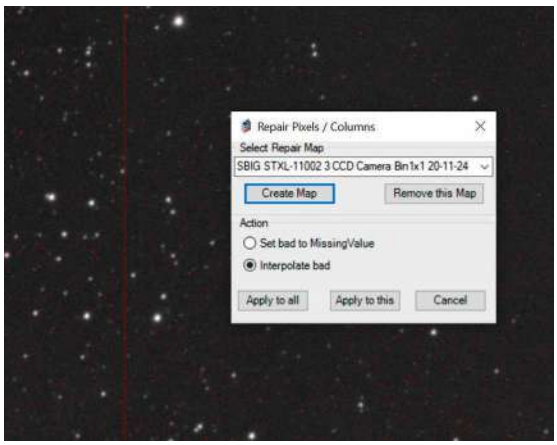
Once the data is collected, the image-processing program CCDStack (**bit.ly/3JeNnus**) can be used to help with the heavy lifting of calibration. The steps are straightforward and it only takes a few minutes to process to your master frames per filter. There are two steps to highlight in the calibration process, which I think make the major difference between ending up with an okay image and producing a great one that stands out.

Removing unwanted artefacts

Firstly, astronomical cameras can have hardware issues in the form of either column defects, bad pixels or hot spots, which effectively leaves gaps in the captured data. You can tackle these issues by dithering – slightly moving the telescope – between the captured photos. This means you can capture the missing detail in your sub-exposures. So, after applying flats, darks and bias frames to each sub-exposure, it's important to neutralise any of these hardware defects in the images prior to combining all the sub-exposures together.

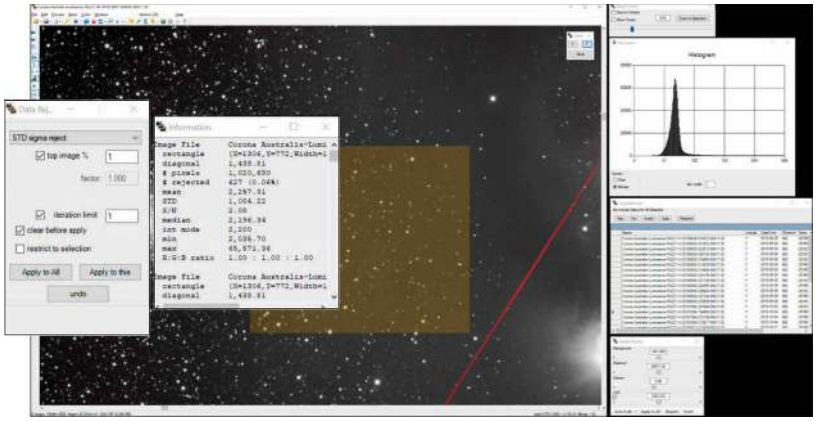
In CCDStack, this function is found under 'Process › Repair Pixels/Columns' (see Screenshot 1). If you then create a Repair Map, by clicking the button 'Create Map', it highlights in red all the defects within the field. Upon applying the tool, it treats each sub-exposure individually to fill in these missing regions, and once applied it provides you a lovely set of clean images, free of hardware defects.

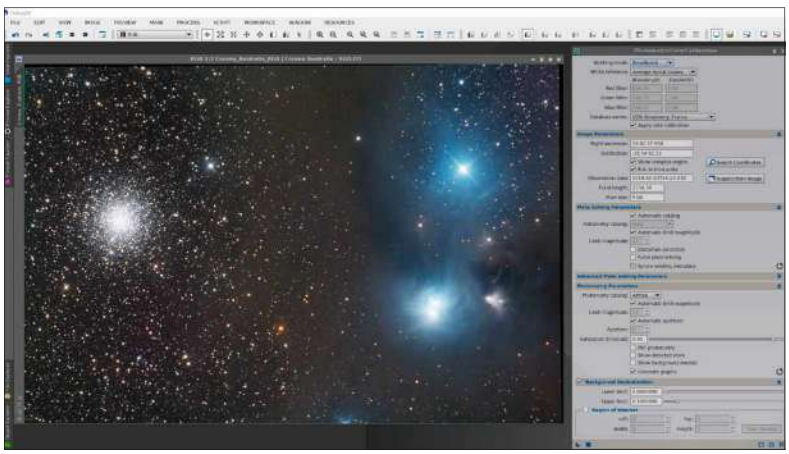
After all the images are aligned, the second most important step is the elimination of any remaining artefacts, for example satellite trails and cosmic rays impacting on the imaging chip while imaging. These items show up randomly and can be removed using their randomness to select them. Under the menu



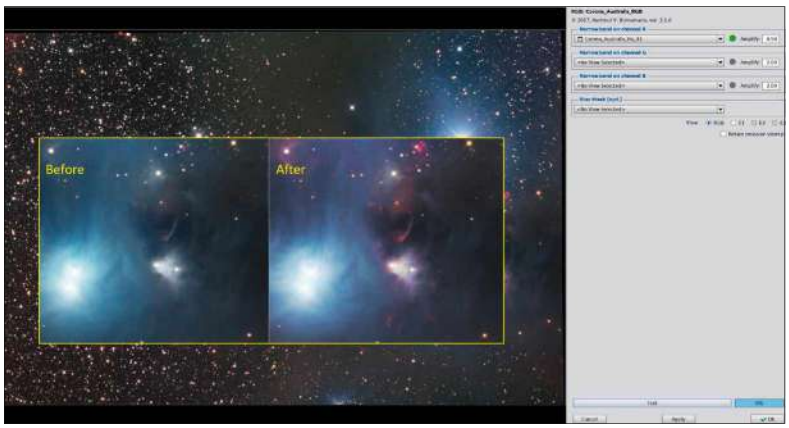
◂ Screenshot 1: in CCDStack use 'Process › Repair Pixels/Columns' to remove unwanted artefacts from across a selection of sub-exposures..

▾ Screenshot 2: ...and use 'Stack › Data Reject' to clear up any that are left over





▲ Screenshot 3: The white balance setting can be adjusted by using 'PhotometricColorCalibration' in PixInsight...



▲ Screenshot 4: ...and 'Red' is added by using 'Emmission Line Integration'

3 QUICK TIPS

1. Plan the target's layout in accordance to your field of view before setting up at your favourite dark-sky site.

2. Correctly calibrate the data to remove imaging chip hardware defects and randomly occurring defects like satellite trails and cosmic rays.

3. Combine narrowband highlights into the broadband colour channels to bring out special features.

item 'Stack › Data Reject' (see Screenshot 2), CCDStack has a large selection of rejection options that can be used accumulatively to tag remaining image defects. What is particularly good is the reported level of rejection in a selected area, so you can review that for each sub-exposure.

After producing each 'master frame' in Red, Green, Blue, Luminance and Hydrogen-alpha, I used both CCDStack and PixInsight (**https://pixinsight.com/**) to combine the data to see which program provided the most suitable, colour-accurate result. Each package has its specific abilities to combine the masters, and I love fully processing images with both programs and then choosing my preferred one.

It is important to remain broadly focused on all the tools within each product, especially in PixInsight, which has powerful processes and scripts to help combine complex colour schemes. This includes those in the batch-processing area that need to be learned to be appreciated: these can help introduce effects that are not easily achieved outside PixInsight. For setting the white balance of the image, I use PixInsight's 'PhotometricColorCalibration' (PCC) process (see Screenshot 3).

An important factor when processing this image was the introduction of Hydrogen-alpha data to highlight nebulous regions. PixInsight's Utility Script called 'Emmission Line Integration' (see Screenshot 4) is perfect for this task, as it allows you to introduce narrowband data to a specific colour channel in a broadband image, in this case Red. This tool enables you to add up to three different narrowband filters to the RGB master, with an 'Amplify' input box that allows you to select the desired strength per filter.

To add finishing touches to an image, I like to combine the final colour master to the high-resolution Luminance and Hydrogen-alpha masters in Photoshop, which I did here. As you can see, there are great products at your disposal to help make your final image your own masterpiece.

Steven Mohr is an astrophotographer based in Melbourne, Australia. He was shortlisted in APY 2021 for his image 'Dark Molecular Cloud in Corona Australis'

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△ The Dark Shark Nebula, LDN1235

Catalin Cosar, Henlow, Bedfordshire, 22–28 February 2022

Catalin says: "Along with the dark Shark Nebula, LDN 1235, two reflection nebulae are visible here, vdB 149 and vdB 150, as well as the distant spiral galaxy PGC 67671, behind the shark's 'fin'. Gathering the data was easy – the moonless nights helped – but processing it was a different story. It took a few weeks until I was satisfied with the final image."

Equipment: QHY 268C and QHY 268M cameras, Takahashi FSQ-85EDX refractor, Sky-Watcher EQ8 Pro mount **Exposure:** RGB 165x 180", L 198x 180" **Software:** StarNet++, PixInsight

Catalin's top tips: "For faint, dusty objects like this, there's no substitute for dark skies, fast optics and lots of integration time (I had over 18 hours). To bring out the nebulosity without distorting the stars, I processed my two stacks, RGB from my colour camera and luminance from my monochrome, separately. Each was stretched and denoised (cleared of unwanted artefacts), then the luminance was deconvoluted (contrast improvement) and the RGB was colour calibrated before combining them. After removing the stars with StarNet++, I stretched them again before adding the RGB stars back in."

◁ Star trails

Andy Parker, Dungeness Beach, Kent, 1 April 2022

Andy says: "This is a superb dark-sky spot on the coast. I had to edit out a couple of aircraft trails using the eraser tool. If you look closely there's a meteor near the tower."

Equipment: Canon EOS RP mirrorless camera, Canon 35mm lens, 3 Legged Thing Punks Travis tripod **Exposure:** stars: ISO 200 f/5.6, 5x 14'; foreground: ISO 100, f/8, 183" **Software:** Photoshop

ISS transit ▷

Julian Whitfield, Bristol, 17 March 2022

Julian says: "This was four years in the making. Finally, a clear sky combined with an ISS shadow transit of 0.61-second duration."

Equipment: ZWO ASI174MM camera, Sky-Watcher 300P Flextube Dobsonian **Exposure:** 8fps, 0.64ms, gain 102 **Software:** Photoshop

◁ The Trifid Nebula

Adriano Almeida, Mississauga, Ontario, Canada, 19 May 2021

Adriano says: "I was especially pleased with how this shows off the surrounding reflection portion of the Trifid Nebula."

Equipment: ZWO ASI2600MM camera, William Optics FLT132 refractor, Sky-Watcher EQ6-R Pro mount **Exposure:** Ha 3h 5', OIII 8h; stars: RGB 2h **Software:** APP, Photoshop

◁ Elan Valley nightscape

Thomas Winstone, Claerwen Dam, Rhayader, 25 March 2022

Thomas says: "The capture of this picture – of the Milky Way, an ISS pass, the Zodiacal Light and a meteor over the Elan Valley – involved a 15-minute off-road drive on a bumpy track and a climb up the valley wall in the dark with walking poles and a head torch."

Equipment: Canon EOS R5 mirrorless camera, Sigma 14mm lens, Gitzo CF tripod **Exposure:** ISO 2000, f/2.2, 8x 25"**Software:** Photoshop, Lightroom

△ The Moon

Roger Hyman, Sparkford, Somerset, 8 March 2022

Roger says: "I love all the details and features to see in this waxing crescent Moon I shot from my back garden."

Equipment: Altair Hypercam 183C Pro camera, William Optics Zenithstar 126 refractor, Celestron CGX mount **Exposure:** 12.5ms, gain 400, 500 frames, best 25 per cent stacked **Software:** SharpCap, AutoStakkert!, Photoshop, Topaz DeNoise AI

LBN 531 and LBN 532 in Cepheus ▷

Yann Sainty, Vosges and Moselle, France, 3–10 March 2022

Yann says: "This is the hardest processing I've ever done, due to mixing the Ha (Hydrogen-alpha) in with the LRGB, and separately processing the planetary nebula."

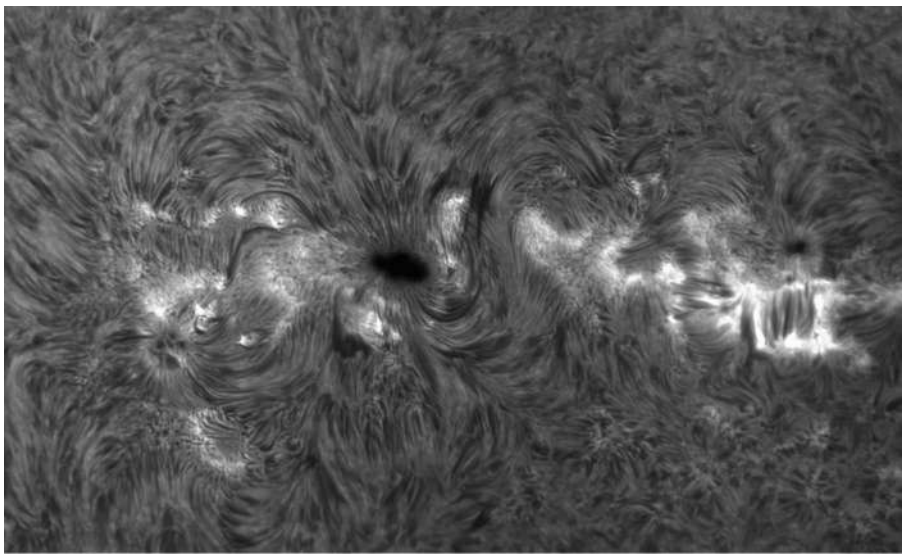
Equipment: ZWO ASI2600MM Pro camera, Takahashi FSQ-106ED refractor, Sky-Watcher ER6-R Pro mount **Exposure:** 65h 45' total **Software:** Siril, PixInsight, Photoshop

The Antennae Galaxies ▷

Basudeb Chakrabarti, via Telescope Live, Hurtado Valley, Chile, 13 March 2022

Basudeb says: "It was very difficult to bring out the details of the core area."

Equipment: FLI ProLine PL9000 camera, Planewave CDK24 astrograph, Mathis MI-1000 mount
Exposure: 4h 20' total
Software: DeepSkyStacker, PixInsight, Photoshop



◁ Sunspots

Arturo Buenrostro, Dallas, Texas, 27 March 2022

Arturo says: "These are the sunspots AR 2975/6, which are part of the fantastic solar activity we are now experiencing in Solar Cycle 25."

Equipment: ZWO ASI178MM camera, Lunt 60mm H-Alpha telescope, double-stacked 50mm filter, B1200 blocking filter, Sky-Watcher AZ-EQ6 Pro mount
Exposure: 50" video, 2,500 frames stacked
Software: AutoStakkert!, RegiStax, Photoshop

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hama

We've teamed up with Modern Astronomy to offer the winner of next month's Gallery a Hama Lens Pen, designed for quick and easy cleaning of telescope optics, eyepieces and camera lenses. It features a retractable brush and non-liquid cleaning element. **www.modernastronomy.com • 020 8763 9953**

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86 **Discover why the WideSky 80 f/6.25 ED refractor punches above its price bracket**

JAMES B. BRECKINRIDGE AND ALEC M. PRIDGEON
WITH STARS IN THEIR EYES
THE EXTRAORDINARY LIVES AND ENDURING GENIUS OF
ADEN AND MARJORIE MEINEL

HOW WE RATE

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★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books on a husband and wife team of American astronomers and the Moon, and a roundup of the latest gear

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WideSky 80 f/6.25 ED refractor

An all-round telescope that works well for visual astronomy and astrophotography

WORDS: CHARLOTTE DANIELS

VITAL STATS

- **Price** £549
- **Optics** ED doublet with fully multi-coated Ohara FPL-53 glass
- **Aperture** 80mm
- **Focal length** 500mm, f/6.25
- **Focuser** Heavy duty dual-speed 2-inch rack and pinion hybrid drive with 10/1 (ratio from coarse to fine) and brass compression ring
- **Extras** Retractable dew shield, 2- to 1.25-inch adaptor, aluminium case, Vixen-style dovetail-profile mounting foot
- **Weight** 2.9kg
- **Supplier** The Widescreen Centre
- **Tel** 01353 776199
- **www.** widescreen-centre.co.uk

We are always very happy to see a telescope arrive for review in a solid carry case, and the WideSky 80 f/6.25 ED refractor's smart, padded suitcase provided us with an excellent first impression when it was unboxed.

Our admiration continued when we looked at the optical tube assembly, which appeared slick, robust and incredibly well made. We were pleasantly surprised, as the WideSky 80 has the look and feel of a telescope worth twice the price. With our curiosity piqued by this new brand, we headed out to begin our tests.

Mounting the optical tube assembly wasn't an issue, although we did feel it would benefit from a slightly longer foot. For observing, this proved ample, but with a DSLR or astro camera attached we struggled to balance the setup as it was bottom-heavy. During our time with the WideSky 80, we opted for tube rings and a longer bar when we used it for astrophotography.

Despite some questionable seeing on a damp night, we were curious to see how the WideSky 80 performed as a visual telescope. Armed with eyepieces, first a 25mm and then a 15mm, we first slewed over to Aldebaran (Alpha (α) Tauri). We could resolve a beautifully crisp and sharp red star in the centre of the field of view with both eyepieces. However, as we nudged our target towards the edge of the field, the appearance did distort slightly. Happily, we saw next to no colour fringing. For a true star test, we headed to the Double Cluster in the constellation of Perseus, the Hero. The WideSky 80 rose to the challenge and returned a lovely delicate view, in which we could appreciate different colours from the yellow and blue-tinged stars within.

Enjoying the sights

With an aperture of 80mm, it is fair to say that this refractor is by no means a 'light bucket' for galaxies, but we did find our way down to the Andromeda Galaxy, M31, on a crystal-clear night. Here we could see a definite, bright smudge of light, but no discernible features. This isn't really surprising, however, for an 80mm refractor, and it still encouraged us to keep exploring the skies. We went on to enjoy the Pleiades, M45, and the Bode's and Cigar Galaxies, M81 and M82, with the WideSky 80 returning a lovely view each time. All in all, we felt it holds its own as a portable, visual telescope. ▸

Integrated dew shield

The retractable, metal dew shield provides 130mm of protection beyond the primary optics. It also ensures ultra-portability. During some damp, spring nights the shield proved efficient at keeping moisture at bay throughout our imaging and stargazing sessions. A small dew heater wrapped around the shield is all that's needed for further protection.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

SCALE

Dual-speed rack and pinion focuser

For astrophotography, the ability to fine focus is always an advantage. The dual-speed focuser helps refine star focus and is smooth to use. Meanwhile, the integrated scale allows users to record the optimal focus point for their camera. The WideSky focuser also comes with a large user-friendly tension adjuster.

Optics

The Ohara FPL53 glass is designed to limit chromatic aberration (an effect usually seen as unwanted coloured rings around brighter objects) and to optimise viewing and image quality, which is further honed with the ED doublet system. In addition, the multi-coated glass elements help to enhance contrast and image sharpness, while minimising light transmission anomalies such as glares and halos.

Two-inch barrel

Ideal for astrophotography, a 2-inch barrel helps to enhance images as it reduces the effect of vignetting. However, it also has advantages for observational astronomy, as it allows the use of lower magnification and wide field eyepieces to optimise views of galaxies. The supplied 1.25-inch adaptor gives flexibility for the use of different eyepieces and diagonals.

FIRST LIGHT

High versatility

The 80mm glass is an ideal aperture for a first astrograph, as it makes the WideSky 80 well-suited to many nebulae, galaxies and star clusters in the Messier and NGC catalogues. Not only does it capture enough light to do justice to many popular deep-sky objects, but it also provides an excellent field of view for those dabbling in lunar photography.

Paired with a cropped-sensor DSLR, a full-frame DSLR, or a designated astro camera, the WideSky 80 is well-adapted to a range of different configurations, and it enables new astrophotographers to develop their skills and invest in camera equipment without the need to upgrade the telescope.

The 500mm focal length ensures the WideSky 80 is suitable for portable and remote observing or imaging, and heavier portable Go-To mounts will cope with the weight of its optical tube assembly. In general, refractors like this tend to cope better than reflectors with transportation. When it comes to tracking accuracy, the focal length allows newcomers to the hobby some leeway. For visual use, the multi-coated optics limit chromatic aberration to ensure the WideSky 80 performs well for both visual astronomy and astrophotography.

Aluminium carry case

The lightweight, robust carry case that is provided is a big bonus for wandering astronomers, allowing you to store the WideSky 80 refractor dust-free and to travel safely with it between dark-sky locations. As well as protection, the foam-padded interior also offers space to store other accessories, including eyepieces, a field flattener and adaptors.

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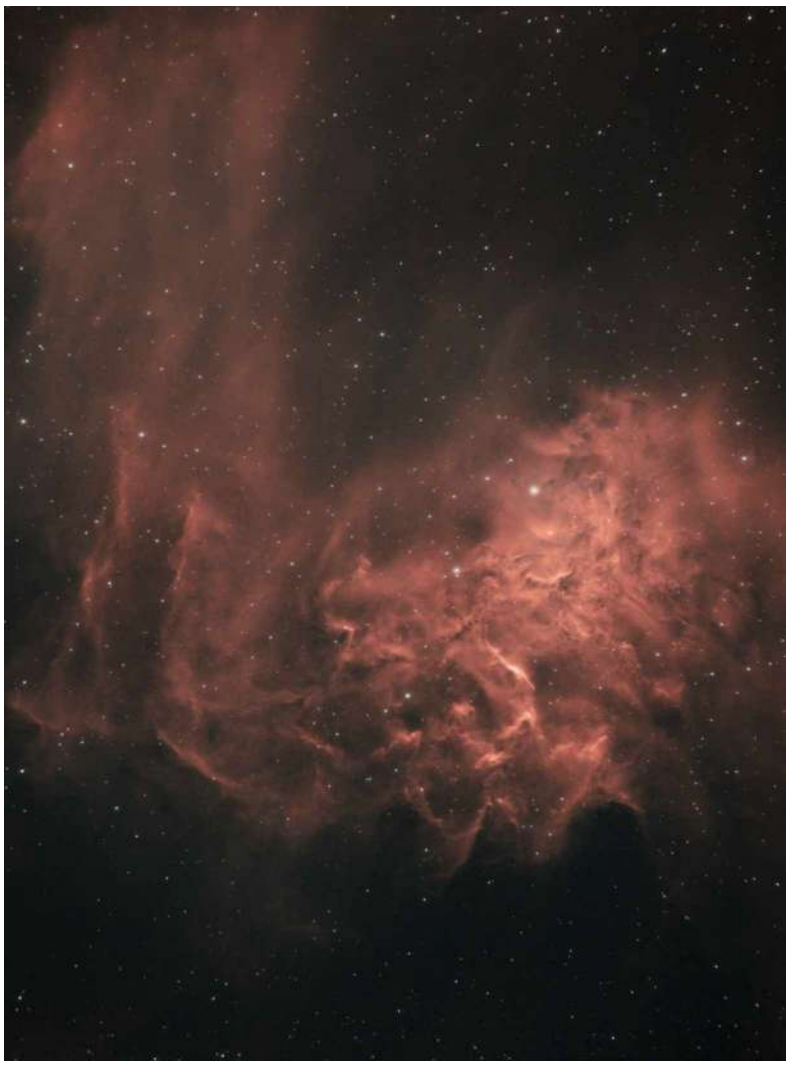

◂ The Flaming Star Nebula, as captured by the WideSky 80 and a Starlight Xpress SXVR H694 mono camera, using 2.5 hours of 5' Ha exposures, and 2 hours of 5' OIII

▲ The M81 (left) and M82 galaxies, captured with the WideSky 80 and a Canon 6D DSLR (using a field flattener), with 1.5 hours of 3' exposures at ISO 2000

▸ Next, it was time to see how the WideSky 80 performed as an astrograph. After training the telescope on the Flaming Star Nebula, IC 405, it provided the perfect field of view while partnered with our CCD camera. Setting up an image proved to be quick and easy, as the dual-speed focuser allowed just the right amount of control for pin-sharp stars. As a result, we were running test exposures in minutes.

Testing for curves

We were loaned the optional field flattener, but we started off without it to see how the telescope performed and noted some star curvature on the edge of the frames. This didn't really seem much of a problem, however, and it is definitely something that can be controlled in post-processing. Afterwards, we decided to swap the astro camera for a full-frame DSLR to see how it faired. Heading over to Markarian's Chain for an hour, we found that the telescope yielded a wide galactic view of this target and its neighbours.

We did indeed see greater curvature, with further elongated (and slightly out of focus) stars at the edges. This isn't unusual when using a full-frame camera, so we thought it was time to pop the field flattener on. This was easy to attach and it did not require additional spacing when paired with the DSLR and T-ring. We were very pleased to see an instant improvement in image quality, with our shot of the Bode's and Cigar Galaxies maintaining sharp stars across the image.

Overall, the WideSky 80 is an impressive telescope with plenty to offer for both new astrophotographers and those a little more seasoned. In our experience, this refractor not only feels like a more expensive telescope, but in many ways it performs like one too. Indeed, we couldn't find fault with the build quality or the ease of use. While the glass is a little curvy, and we'd have liked a couple more accessories, the WideSky 80 was a pleasure to use. At no point did we feel it limited our experience, nor did it disappoint with the results it provided. The WideSky 80 is a truly rewarding scope that punches well above its price.

▲ Markarian's Chain captured with the same setup, but using the Canon 6D DSLR without a field flattener, with 1.5 hours of 3' exposures at ISO 2000

VERDICT

Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★☆
Imaging quality	★★★★½
Optics	★★★★☆
OVERALL	★★★★½

KIT TO ADD

1. WideSky Field Flattener T2

2. Finderscope Dovetail Mounting Foot

3. William Optics 2-inch DuraBright Dielectric Carbon Fibre Diagonal

FIRST LIGHT

iOptron Photron RC6 6-inch Ritchey-Chrétien optical tube

Is this small, portable telescope equally capable of viewing and imaging?

WORDS: TIM JARDINE

VITAL STATS

- **Price** £399
- **Optics** Ritchey-Chrétien Cassegrain
- **Aperture** 150mm (6-inch)
- **Focal length** 1,370mm, f/9
- **Focuser** 2-inch dual-speed Crayford
- **Length** 490mm
- **Weight** 5.4kg
- **Supplier** Rother Valley Optics
- **Tel** 01909 774521
- **www.**rothervalleyoptics.co.uk

The Photron RC6 is the smallest telescope in iOptron's Photron RC range, and this review looks at how it performs when used with eyepieces and a camera.

When the Photron RC6 arrived, we immediately inspected the alignment of the mirrors. These are initially collimated at the factory, and then Rother Valley Optics (the supplier of the review model) re-checks each telescope on an optical test bench. Our initial check was conducted during the day with a Cheshire eyepiece, and then we re-tested the alignment using a suitable star once darkness had fallen. The tests confirmed the review model was in good condition and the collimation was near perfect. Any adjustments to the alignment of the primary and secondary mirrors can be made with an Allen key, but this shouldn't need to be done too often.

It's impossible to ignore the solid construction of the Photron RC6: the tube is steel with metal fittings at either end and there's nothing flimsy about the design. The secondary mirror holder is held in place by sturdy 2mm steel struts, which show no sign of flopping or flexing in any orientation. Straight out of the box, the optical tube weighs nearly 5.5kg, but once it's configured for use that weight increases, especially towards the rear of the telescope. The mount we used, like many, performs best when the telescope is nicely balanced, and to achieve this we attached additional weights at the front.

Steady focus

The Photron RC6 took around an hour to acclimatise, but once it had settled down we found that there was very little variation in focus over the course of a few hours' use. Periodic checks during an imaging session revealed that only micro-adjustments were needed.

The Photron RC6 can be used for observing and imaging. Taking advantage of some clear moonless nights, we attached a colour camera and set about taking some pictures. Despite its petite dimensions, the Photron RC6 has a focal length of 1,370mm, which makes it capable of picking up smaller deep-space objects, such as galaxies, planetary ▸

Vixen-style dovetail bar

The Photron RC6 features a full length, Vixen-style dovetail bar, in a stylish, matching anodised-red finish. The bar is attached via permanent brackets and adds rigidity to the optical tube, solidly supporting the telescope and any accessories you may wish to attach to it.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

Knife-edge baf es

Seven knife-edge baffle rings sit snugly together inside the optical tube, but aren't permanently attached to the tube walls. Their role is to reduce, or 'baffle', any stray light that may enter the tube. The rings help to increase contrast at the eyepiece, producing a clearer view of faint objects.

Finder shoe

A finderscope is a useful addition to a long focal-length telescope like this. There isn't one included in the package, but a standard finder shoe is provided and it can be positioned on either side of the focuser to suit your preference or mount type.

Focuser

The dual speed 2-inch focuser is a Crayford design and can be rotated into position with the large, knurled ring. It's smooth in operation and the tension is easily adjusted, while the 1:10 reduction gear allows smooth and accurate fine focusing. The locking thumbscrew holds the focuser firmly in place once it's been set.

FIRST LIGHT

Extension tubes

The Photron RC6 is supplied with 2x 25mm and 1x 50mm extension tubes, which have a generous thread for accurate attachment to the rear of the telescope. The tubes allow a variety of accessories to be used with cameras and filter wheels, as well as letting you attach diagonals and eyepieces.

Ritchey-Chrétien mirror design

First introduced over a century ago, Ritchey–Chrétien telescopes have become a design of choice for professional telescopes, including the European Southern Observatory's Very Large Telescope and even the Hubble Space Telescope. The reason for its popularity is the combination of hyberbolic concave primary and convex secondary mirrors, which, unlike other designs, achieves an image free of distortions caused by spherical aberrations and coma.

Modern manufacturing processes have made it possible to produce these mirrors for amateur instruments and a Ritchey–Chrétien telescope might just present the optimal choice for an amateur. For example, a 6-inch (150mm) refractor with glass lenses that can produce comparable coma and chromatic aberration–free images would typically be much more expensive and much easier to transport.

Of course, any telescope style is a compromise to some extent but, pound for pound, the photographic and visual performance of the Photron RC6 ticks more boxes than its rivals. It warrants serious consideration, especially for first-time telescope buyers looking for an instrument

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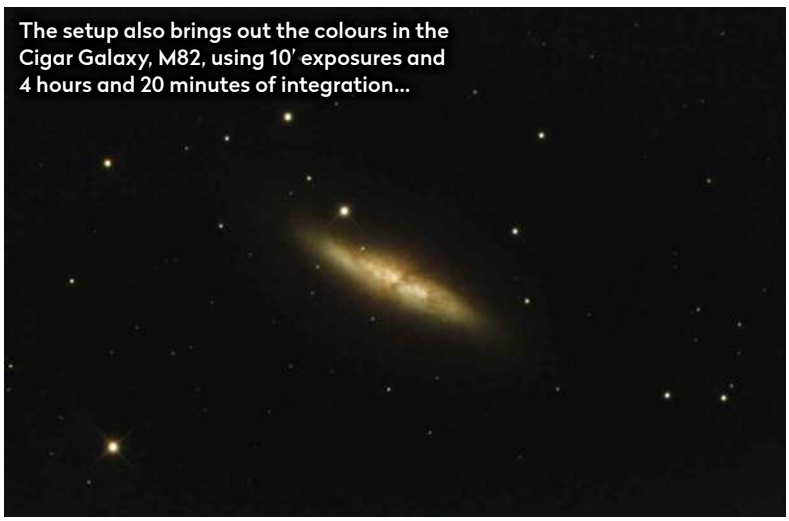
The Orion Nebula, M42, captured with the Photron RC6 and an Atik 460EX OSC camera, using 5' exposures and 35 minutes of integration

▲ M13 is nicely presented with the same setup, using 10' exposures and 2 hours and 10 minutes of integration



The setup also brings out the colours in the Cigar Galaxy, M82, using 10' exposures and 4 hours and 20 minutes of integration...

▲ ...and Bode's Galaxy, M81, using 10' exposures and 2 hours and 30 minutes of integration

▸ nebulae and globular clusters. We took a few images of the Trapezium Cluster in Orion and the Photron RC6 produced good, round stars and nice, sharp edges on the nebulosity.

From there, we moved on to globular clusters, with M3 and M13 presenting nicely at the scale offered. We also managed to capture a few frames of Bode's Galaxy, M81 and the Cigar Galaxy, M82. It struck us that the Photron RC6 would make a perfect setup option for imaging Messier objects, especially as it works so well with a colour camera and can be so easily transported to darker sky sites.

After proving its capabilities with a camera attached (the f/9 optics helped produce well contrasted images even with less-than-ideal suburban skies), we fitted a star diagonal and tried a selection of eyepieces. Starting with a 21mm wide-angle eyepiece, we found the view of a 75%-illuminated waning Moon was very pleasing at 65x magnification, with plenty of good natural colours and sharp detail on display, both around and within craters. Despite a fairly low elevation and moderate seeing conditions, the suggestions of craterlets within Plato held our attention for some time.

Our favourite view came with a 13mm eyepiece, which gave the lunar disc an almost three-dimensional appearance at 105x magnification, while globular clusters M3 and M13 presented a rewarding spectacle that seemed to fill the view, even in the moonlight. A 10mm eyepiece working at 140x magnification pushed the seeing limits, but it was still able to present the glorious colours of a few red stars very nicely, particularly Betelgeuse (Alpha (α) Orionis) and Arcturus (Alpha (α) Boötis).

There's no doubt that the Photron RC6 is a very capable telescope, suitable for both imaging and visual use. And at this price point it'll appeal to both seasoned astronomers and newcomers alike.

VERDICT

Build & Design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Imaging Quality	★★★★½
Optics	★★★★½
OVERALL	★★★★☆

KIT TO ADD

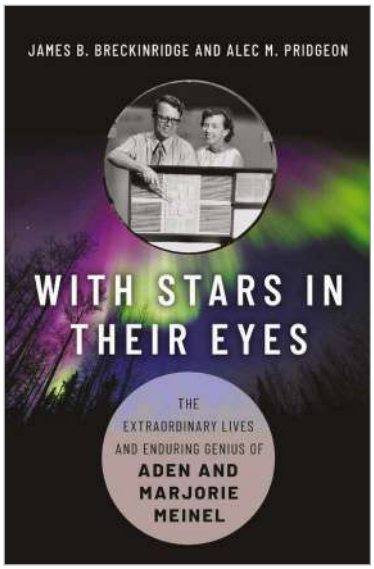
1. iOptron 8x50 Finderscope and Bracket

2. iOptron Electronic Focuser for RC Series

3. iOptron 2-inch Dielectric Mirror Diagonal

New astronomy and space titles reviewed

BOOKS


JAMES B. BRECKINRIDGE AND ALEC M. PRIDGEON
WITH STARS IN THEIR EYES
THE EXTRAORDINARY LIVES AND ENDURING GENIUS OF
ADEN AND MARJORIE MEINEL

With Stars In Their Eyes

James B Breckinridge; Alec M Pridgeon
Oxford University Press
£29.99 ● HB

Husband and wife teams in the history of astronomy are common. What is rare however, is to see credit shared. This book tells the story of Aden and Marjorie Meinel, a pair of astronomers who, through Aden's career, played a significant role in many major observatories across the US in the mid-20th century. Until now, little has been written about them: indeed, Marjorie doesn't even have a Wikipedia entry, yet.

This book examines the Meinels' working lives in more or less chronological order, beginning with a long chapter on genealogy, passing through Marjorie's family connections (her father was an astronomer at Mount Wilson observatory) and Aden's war work, before focusing for the bulk of the book on Aden's professional life and Marjorie's support. This book is hugely detailed, giving an intricate insight into Caltech, the Kitt Peak National Observatory and all the other places where Aden worked and with which he was involved. Aden's (though not Marjorie's) war work is similarly fleshed out in considerable detail.

As a joint biography however, there are omissions. Marjorie's life, particularly how she felt about her role and how together they juggled family responsibilities (they had seven children) and astronomy does not get much attention. Had this been a biography of Aden, I would have been full of praise for the recognition the authors have given to Marjorie's contribution to Aden's work. To call it a joint biography, however, could be seen as a little disingenuous. Marjorie had the chance to become a professional astronomer in her own right but gave it up to become, as the authors put it, a "homemaker" and supporter of her husband's career. Surely, she must have had some reasons and some feelings about that. These are not explored.

▲ **A match made in the heavens: the astronomers Marjorie and Aden Meinel**

To conclude, this book gives some fantastic insight into the inner workings of the American astronomical world in the 20th century. It shows how work was developed, and the way these institutions ran. The book however, lacks personal detail. There is too little about their personal feelings and ambition, especially of Marjorie's, to make it fully feel like a biography. ★★★☆☆

***Emily Winterburn** is author of The Quiet Revolution of Caroline Herschel: The Lost Heroine of Astronomy*

OSA HISTORICAL ARCHIVES

Interview with the author
James B Breckinridge

What were Aden and Marjorie's major achievements?

Aden used tools of his own design to discover that aurorae are caused by the streaming of particles from the Sun to excite ions in the uppermost atmosphere. He built telescopes and instruments revealing the physical and chemical composition of the Universe. At NASA he and Marjorie collaborated on next-generation space telescopes, propulsion systems and space science mission concepts.

What were they like as people?

I met Aden in 1968 when he was at Steward Observatory and director of the Optical Sciences Center. He felt that students needed to know how to design, manufacture and test optical instruments. He travelled, but when he was in the office he was always accessible. At NASA they shared a large office with an open-door policy, welcoming all scientists and engineers in conversation. They did not engage in small talk but cut to the chase, often responding with insightful questions. Aden came up with many ideas; Marjorie filtered these from a practical perspective. They published hundreds of papers and six books. Both were focused and dedicated as a close-knit team.

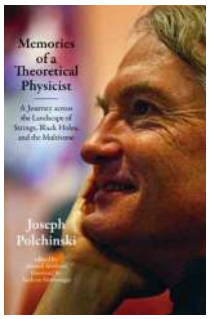
Today, what would excite them most?

They would be most excited about recent developments in space telescopes, particularly the elimination of diffraction noise at the image plane by using innovative segmented telescopes to characterise terrestrial exoplanets and search for the indicators of life beyond our Solar System.

***James B Breckinridge** is Adjunct Professor in the College of Optical Sciences at the University of Arizona*

Memories of a Theoretical Physicist

Joseph Polchinski; Ahmed Almheiri
MIT Press
£22 ● PB



Memories of a Theoretical Physicist is a rather understated title for the memoir of the remarkable Joe Polchinski. Don't let the modest title fool you though, for Joe was hardly just a theoretical physicist. He invented D-branes, and with them changed the course of modern theoretical physics, and in particular string theory. His numerous contributions have been recognised by many prestigious prizes, which highlight his brilliance. But this memoir also showcases his love for his family and sport.

The book follows Polchinski throughout his professional life – told in his own voice – with chapters separated by stages of his career. He remembers precisely when certain ideas came to him, what the state of field was at the time and the contributions of people he worked with. The level of detail is impressive, and even more remarkable given that he had to dictate it because brain cancer had robbed his ability to read and write.

Following the explorations of a theoretical physicist can be confusing, as the topics are advanced. There are additional explanations of the physics concepts, but these are pitched to a high level that limits the book's accessibility. Unless you know about string theory already, you might find it hard to follow. However, the book is charming, and could inspire a new generation of physicists by relating the accounts of an "exceptional scientist and human being". ★★★★☆

***Laura Nuttall** is a senior lecturer in gravitational waves at the University of Portsmouth*

The Squirrel That Watched The Stars

Tom Kerss; Anni Betts
Stargazing London
£9.93 ● PB

GREAT FOR KIDS

For most of us, our introduction to astronomy comes as children, gazing up at the stars and wondering just what those bright specks in the night sky are. This sense of curiosity and wonder is at the heart of a new children's book by astronomer and writer Tom Kerss.

As a narrative poem it tells the story of a squirrel who looks up at the stars from his home in London's Greenwich Park. Down from the heavens comes Cygnus the Swan, who gives the squirrel and the reader a lesson in stellar science.

We learn there are more stars than can be counted, that stars are born in gas clouds, that they are different colours and that our very own Sun is a star.

The story is beautifully told in a simple poetic style, capturing the awe felt by a tiny creature like a squirrel – or indeed a human – when confronted by the cosmos. Anni Betts's accompanying artwork is wonderful and really comes to life when depicting our companion Cygnus and other glittering constellations.

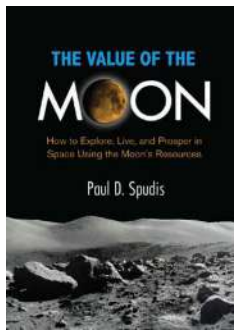
A short epilogue reiterates the science we've learned in simple language, and there's a call to action too, inviting the reader to find Cygnus in the night sky for themselves.

This is a captivating children's book and a great introduction to astronomy, while its subject matter and soothing rhyme scheme make for a good night-time story. But the biggest praise I can give is to repeat the words of my two year-old, who at the book's close simply looked up at me and said: "Again!" ★★★★★

***Iain Todd** is* BBC Sky at Night Magazine's *Staff Writer*

The Value of the Moon

Paul D Spudis
Smithsonian Books
£16.99 ● PB



The Moon is one of the brightest objects in our night sky and, at only 385,000 kilometres away, is the nearest celestial object to Earth. It's no wonder that for centuries it has been watched, studied and discussed. But what value does the Moon have for us? Probably more than you think. *The Value of the Moon* answers this question in a thoughtful, clear and interesting way, and yet despite its short length (the main text being only 210 pages long), there is a great deal to learn and digest.

Paul D Spudis covers a range of topics, including the origins of the Moon, the successful launches of the Apollo programme and why the Moon was consequently abandoned. He explores the political and fiscal aspects that challenged and shaped future missions, but makes one thing clear: the Moon is an untapped resource. Spudis explains why this is so by highlighting three of the principal advantages of Earth's natural satellite: it's close, it's interesting and it's useful. The Moon, as the author puts it, "is always available": it allows frequent launches; it can be exploited for its materials and resources; and, of course, it holds great scientific value.

The Value of the Moon will intrigue anyone with an interest in spaceflight and our future relationship with our natural satellite. It would have been interesting if Spudis had incorporated space law into the text but nevertheless, the enthusiasm and knowledge with which he writes is impressive and will undoubtedly challenge the reader to form their own opinions on utilising the Moon for the benefit of humankind, positive or negative. ★★★★☆

***Katrin Raynor- Evans** is an astronomy writer and Fellow of the Royal Astronomical Society*

Ezzy Pearson rounds up the latest astronomical accessories

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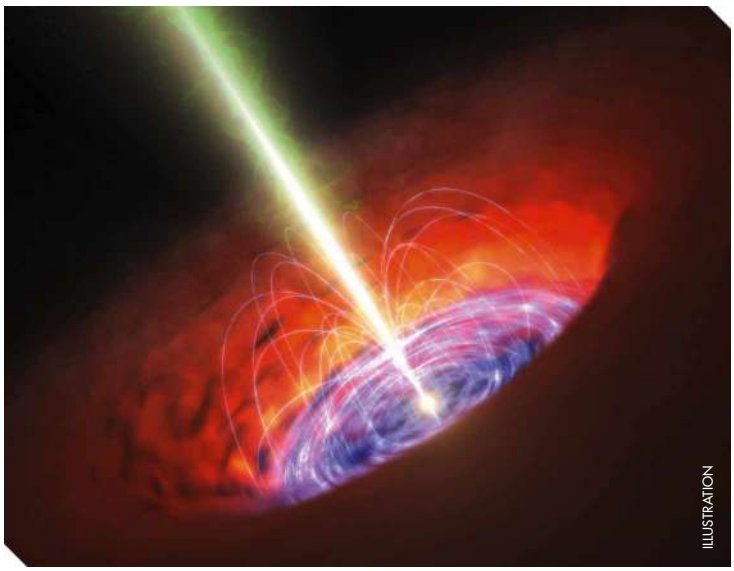
Melissa Brobby interviews Joanna Piotrowska

Q&A WITH A GALAXY EVOLUTION SCIENTIST

The mystery behind how black holes could be bringing a halt to star formation is now being unravelled

How are supermassive black holes in the centres of galaxies preventing the birth of new stars?
When gas falls onto a supermassive black hole, it settles into an accretion disc due to the angular momentum present in the system. Matter in these accretion discs becomes hot, reaching temperatures of above one million degrees Centigrade. This hot gas emits high-energy radiation, which can launch 'winds' from the accretion disc that move at high speeds away from the black hole. These winds can potentially push gas out of galaxies – causing galactic 'outflows'. In this way black holes with accretion discs, known together as Active Galactic Nuclei, can potentially remove the fuel needed for future star formation.



ILLUSTRATION

▲ **The jets of high-energy material ejected from supermassive black holes may prevent gas around galaxies from cooling and accreting to form stars**

What other effects can Active Galactic Nuclei have on a galaxy?
With the help of a galaxy's magnetic field, supermassive black holes can launch jets of high-energy, charged particles from the accretion discs along the axis of rotation of the black holes. These jets can interact with the galactic gas, injecting turbulence and heating it up. The jets extend large distances and can interact with the gas outside their home galaxies too. They heat that gas up and prevent it from cooling down to accrete onto the galaxies themselves – depriving them of star-forming fuel.

The mechanism through which black holes prevent star formation is unknown, but our research indicates that black holes are likely to kill star formation through a combination of heating and turbulence injection, which both decrease the reservoirs of gas available for star formation, and reduce the efficiency with which the gas collapses to form new stars.

How could the decrease in star formation affect a galaxy in the long term?
If a galaxy continues to decrease its star formation rate, it will eventually end up barely forming new stars at all. It will then continue to exist until previously formed stars reach the end of their stellar evolution cycles. What this means for our observations of these galaxies is that they will become dominated by old stellar populations and become 'redder' in their observed colour. The decrease in star formation is also associated with the loss of star-forming gas, so galaxies that are not actively forming stars have smooth light distributions.

How do supermassive black holes behave at the centres of galaxies?
We analysed the behaviour of dense, star-forming gas in two simulations – Illustris and IllustrisTNG – and compared it to observations from the Sloan Digital Sky Survey. We found that Sloan showed both gas reservoirs and star formation efficiency decreases the more massive a black hole is, but none of the simulations were a close match with the observations.

By comparing the observable predictions of different implementations of black hole physics with the observable Universe, we can either rule out or support some models for the interaction between black holes and their host galaxies, which can tell us how supermassive black holes act. If the observable Universe had been a perfect match with theoretical predictions, we would likely have a correct physical model already at hand.

What's next for this research?
We are looking at the details of how black holes operate on a galaxy-by-galaxy basis, comparing the IllustrisTNG galaxies with observations of dense gas on a resolved scale in the ALMaQUEST survey of local galaxies. Here, we will be able to see whether the signatures of black hole operation in the simulation matches the trends in the observations. If we find striking disagreements between the simulated and observed galaxies, this will inform future theoretical models. Characterising these differences will help us to understand the details of how black holes prevent galaxies from forming stars at a range of physical scales in and around galaxies.

Joanna Piotrowska is a PhD candidate at the University of Cambridge whose field of research is in galaxy evolution and processes preventing star formation in galaxies

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Locate Polaris Australis, the 'South star', and the False Comet, a collection of stars in Scorpius

When to use this chart

1 June at 00:00 AEST (14:00 UT)
15 June at 23:00 AEST (13:00 UT)
31 June at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JUNE HIGHLIGHTS

Mercury makes a return to the morning sky in June. Mid-month it reaches a maximum altitude of 10° an hour before sunrise. On the 22nd, Mercury gives Taurus's face (the Hyades) a bright left 'eye' (Aldebaran (Alpha (α) Tauri) being the right 'eye'). Observe Mercury's changes through a small scope. On the 5th it shows a thin phase, 10.6 arcseconds across (at mag. +2.0); by the 25th the disc has shrunk to 6.8 arcseconds and its phase grows to a first quarter Moon shape.

STARS AND CONSTELLATIONS

We may know the False Cross, but have you heard of the False Comet? It lies within the Fishhook asterism in Scorpius (the tail of the Scorpion south of Epsilon (ε) Scorpii). Best observed through small binoculars, its bright 'head' is the compact open star cluster NGC 6231 on the 90° bend of the Scorpion's tail. The False Comet's tail is formed by the adjacent, large (2°) open star cluster Collinder 316, which stretches off in the direction of the double star, Mu (μ) Scorpii.

THE PLANETS

The early evening has no planetary action until Saturn's arrival, rising around 22:00 midmonth. Next to appear is Neptune about midnight, followed by Jupiter an hour later. Jupiter and Mars commence June 1.5° apart. They slowly separate as Jupiter gains altitude, closing the month 20° apart. Switching closer to dawn, Venus dominates the northeastern sky, with Mercury making a brief visit (see above). Uranus returns to the morning, passing Venus on the 12th (1.5° apart).

DEEP-SKY OBJECTS

The South Celestial Pole (SCP) has its own Polaris, but 3 magnitudes fainter than the Northern Hemisphere one. Sigma (σ) Octantis (RA = 21hr 8.3min, dec. = -88° 57') or Polaris Australis, lies 1° from the SCP. It forms a trapezium (3° long) with three other mag. +5.5 stars. Mid-June evenings find this asterism orientated with Sigma in the top right position then, going clockwise, Tau (τ), Upsilon (υ) and Chi (χ) Octantis (top left).

Moving 6° north from Chi (χ) Octantis finds a distinctive binocular double of Pi¹ and Pi² Octantis. This pretty, matched pair of mag. +5.6 yellow stars are 0.2° apart. Continue northwards by 0.9° and you'll find globular cluster IC 4499 (RA= 15hr 0.3min, dec. = -82° 13') in Apus, the Bird of Paradise. This 10th magnitude cluster is a faint glow (5 arcminutes across) with central brightening and a mag. +10.2 star on its southwestern edge.

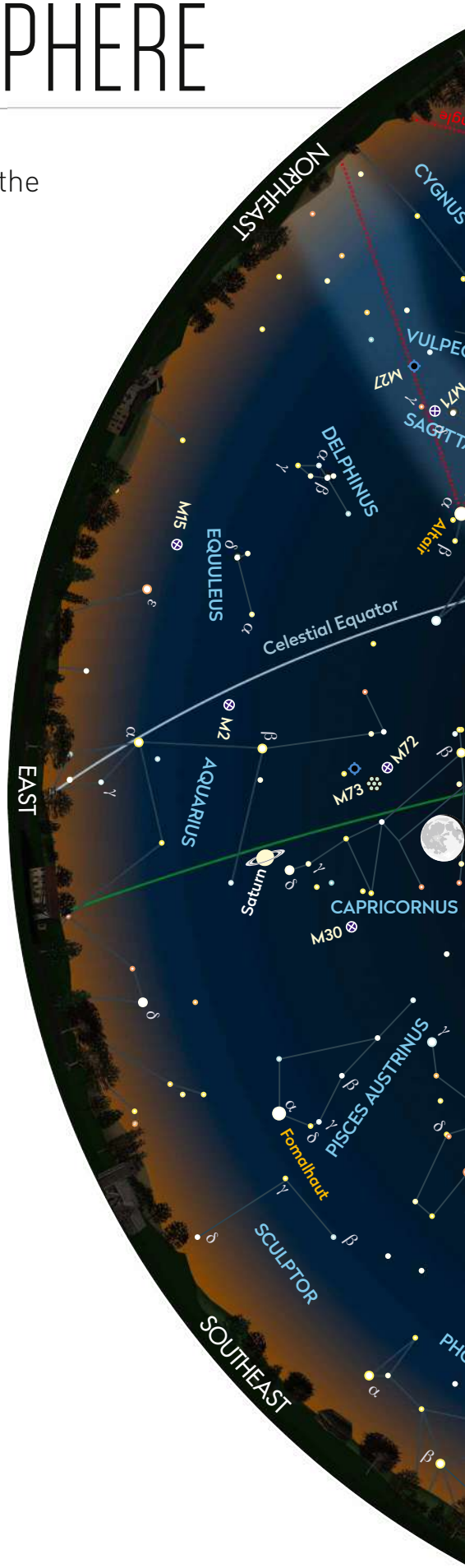

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Summer Triangle
Vega
Keystone
HERCULES
M92
M13
LYRA
M57
Albireo
CYGNUS
CULA
BOÖTES
Kite
Arcturus
BOREALIS
CORONA
COMA BERENICES
M3
M53
Rasalgethi
Rasalhague
Coffin
OPHIUCHUS
SERPENS CAPUT
SERPENS CAUDA
AQUILA
M5
M12
M10
M14
M107
M11
SCUTUM
M16
M17
M18
M9
M23
M20
14th
M8
M6
M7
Teapot
M75
17th
SAGITTARIUS
False Comet
Fish Hook
Collinder 316
NGC 6231
Antares
Barnard 228
SCORPIUS
LIBRA
11th
Ecplitic
Spica
M104
VIRGO
M61
8th
Realm of Galaxies
M100
M60
M58
M87
M86
LEO
CORVUS
M83
M68
CRATER
HYDRA
TELESCOPIUM
CORONA AUSTRALIS
ARA
NORMA
Rigel Kent
LUPUS
Omega Centauri
NGC 4945
Hadar
CIRCINUS
CENTAURUS
CRUX
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Coalsack
MUSCA
TRIANGULUM AUSTRALE
APUS
ANTLIA
INDUS
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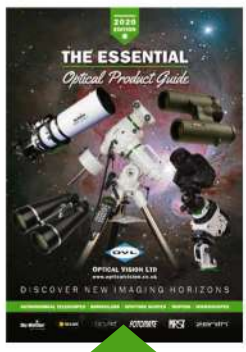

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